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HYGROSCOPIC SEEDS.

By Rev. Alex. S. Wilson, M.A., B.Sc.

HYGROSCOPIC movements depend mainly on changes in the humidity of the atmosphere. Air of any given temperature is only capable of absorbing a definite amount of aqueous vapour; when that amount is present the air is said to be saturated, and evaporation ceases. As the temperature rises in arithmetical progression, the quantity of vapour which the air is capable of retaining is found to increase in a geometrical ratio; hence evaporation mounts up rapidly as the temperature rises; hence, also, when two saturated currents of different temperatures mingle, they are no longer able to retain as much vapour as they did separately, and precipitation consequently occurs in the liquid form. Barometric pressure also affects evaporation; the rate diminishes as the pressure increases. Since these atmospheric conditions are so liable to change, the rapidity with which evaporation takes place must be subject to incessant fluctuation.

As it is the superficial layer alone which furnishes vapour, the rate at which any body yields up its water to the atmosphere depends on the extent of surface which it exposes. The force of adhesion must also be taken into account. A porous body like charcoal condenses atmospheric vapour even at ordinary temperatures; deliquescent salts, too, abstract water from the air. The nature of the surface exposed to the air is also of importance; even the thinnest film of oil or grease prevents, or, at least, greatly reduces, evaporation. Water holding substances in solution also evaporates more slowly than when perfectly pure. These considerations show that the equilibrium of humidity depends on a number of circumstances which must vary in different bodies and at different times in the same body.

Organic bodies containing water very commonly increase or diminish in size as the proportion varies. From their peculiar structure some tissues retain water tenaciously; others readily part with it to the atmosphere. There are, also, great differences in their powers of reabsorption, some being unable to recover their lost moisture, even when it is presented to them in a liquid state, while others speedily imbibe what they lost in drying. Substances such as wool, hair, and feathers are extremely sensitive in this respect, especially if perfectly free from oil or resin; they respond to very slight atmospheric changes and are described as hygroscopic.

Organized structures are rarely, if ever, homogeneous; it therefore frequently happens that one part of an organ contracts or expands more rapidly than the rest. In this way tensions arise within the organ causing it to split, or the organ may alter its shape and exhibit motion. Hygroscopic phenomena are further complicated on account of the intricacies of microscopic structure. A violin string is rendered slacker if moistened, whereas a rope tightens. In the former the molecules of water are apparently introduced chiefly in the direction of length; in vegetable fibres they go rather to increase the thickness. The effects of imbibition are augmented in cellular tissue by endosmose. As the quantity of fluid contained in a closed cell increases the elastic cell-membrane becomes distended and the volume of the cell is enlarged. The range of expansion arising from turgescence is, however, inconsiderable in comparison with the expansion caused by simple imbibition; moreover, turgescence can only occur in closed and thin-walled cells. The cells of which wood is built up have open pores; any change of dimensions must therefore be brought about entirely by imbibition or desiccation taking place in the perforated cell-walls. In cartilaginous or collenchymatous tissues the greatly thickened cell-walls contain a large proportion of water; they contract strongly in drying and swell very much from imbibition.

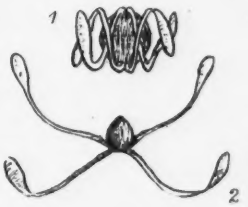

Fig. 1.—Spores of Equisetum. 1. In dry state. 2. With Elaters expanded after moistening (magnified).

Of hygroscopic action we have a familiar example in the warping of unseasoned timber, where the bending is caused by the younger sap-wood on the one side contracting at a different rate from the older heart-wood on the other. Hairs and fibres are especially prone to bend and twist as they dry. Every angler knows how catgut unbends and straightens when put into water. Advantage is taken of this property in the simple old-fashioned weather-glass alluded to in Cowper's lines:—

> "Peace to the artist whose ingenious thought
> Devised the weather-house, that useful toy!
> Fearless of humid air and gathering rains,
> Forth steps the man."

Good weather is indicated by the appearance of a small female figure at one door, rain by the figure of a man coming out at the other. The figures are attached to a

support suspended by a fibre of catgut, which twists and untwists according to the state of the atmosphere. The instrument is really a hygroscope or hygrometer indicating the humidity of the air, and the figures are made to swing round by hygroscopic action. The proportion of moisture present in the atmosphere can be ascertained with far greater precision, however, by means of the wet-bulb hygrometer or by Daniell's dew-point hygrometer.

The dehiscence of seed capsules is brought about by the contraction of their outer walls, and this often takes place in such a way that the seeds are violently expelled, as in the ripe pods of the broom, vetch, and bird's-foot trefoil. At the moment of dehiscence each half of the legume or pod suddenly twists itself, scattering the seeds with great force. The fruit of the common dog-violet is of interest; each of its three valves, when the fruit opens, has a double row of seeds. The valves are boat-shaped; in drying they contract till the seeds are so closely jammed in and the tension becomes so great that the slightest touch causes them to be shot up into the air. The seed vessel of Veronica, on the other hand, remains closed in dry weather, but opens and discharges its seeds in wet. The application of moisture also causes the stellate capsule of Mesembryanthemum to open up. Instead of opening to allow of the escape of its seeds, a many-seeded fruit may become broken up into indehiscent pieces, each containing a single seed. The fruit of the dead-nettle, called a carcerulus, splits up in this way into four little nutlets. In some of the Labiatæ, such as self-heal, *Prunella*, the nutlets are retained within the calyx, which remains closed while the weather is fine; rain, however, causes the sepals to open up and the nutlets are discharged. The fruits of the Geraniaceæ, or cranes'-bills, are also schizocarps, as these splitting fruits are called. These plants are named from the long beak or carpophore of their peculiar fruit. To this beak the five one-seeded carpels at first adhere, but when ripe their basal portions separate from it and curve upwards. At the same moment each carpel splits open along its inner edge, and by the suddenness of the movement the seed is projected out to a distance of some feet. A few species have indehiscent carpels, which themselves spring away from the carpophore. This is what happens in the stork's-bill, *Erodium*, a rather common plant belonging to the geranium family. The fruit of Erodium is, perhaps, the most interesting of all the hygroscopic class. When it springs away from the carpophore in the manner just described, the carpel of Erodium is seen to have a long slender filament or awn, which is in the act of curling upon itself. After the carpel alights its awn continues to curve and twist for a minute or two, until at last it acquires a corkscrew form and comes to rest. As long as the awn is kept dry it does not change, but if moistened with a drop of water it immediately begins to straighten out, and in the course of a very few minutes becomes quite straight. Two or three long slender hairs near the base of the awn keep the carpel in position, with its sharp point directed obliquely into the soil. If now, as in all probability is the case, the upper extremity of the awn presses against some object which affords a point of resistance, the moistening, in consequence of the untwisting and elongation of the awn, forces the point of the carpel down into the earth. Should the soil after a time get dry, the awn will once more assume its corkscrew condition; but instead of the seed being drawn up by this shortening of the awn, the latter is itself drawn down, for the seed holds on and keeps all it gains, its point being barbed like a harpoon. The chances are now that the upper extremity of the awn has been applied to a new point of resistance, so that the next rain will send the seed still deeper into the soil, and so on with every succeeding change of weather. The awn in some species is feathered at its extremity, the more certainly to secure that it shall press against a resisting object when it begins to unwind. Species of anemone and clematis have awned seeds or achenes capable of burying themselves in this manner. The feather-grass (*Stipa pennata*) has the same peculiarity; we have found its seeds stuck deep in the ground like so many darts. Seeds of this description, several of which have been used in the construction of hygroscopes, may literally be said to screw themselves into the earth. The grains of the barren oat and some other grasses have hygroscopic awns by means of which they move about from place to place. During damp weather a heap of these grains disperse themselves in a most surprising manner, marching off in various directions like so many flies. In other cases, as in the common vernal grass and one or two others, the seed trips about in quite fantastic style. Many aristate grains and seeds appear, however, to be adapted for dispersion through animal agency. Even in such cases the hygroscopic property is useful; it enables the seed to burrow into fur or wool the better to ensure its transport. A remarkable splitting fruit is that of *Hura crepitans*, called the "monkey's dinner-bell" because its woody carpels when quite dry separate suddenly with a noise like the report of a musket. The common wood-sorrel has the testa or outer coat of its seed elastic; if touched, this suddenly ruptures, and the core of the seed is projected to some distance. The hairy cress (*Cardamine hirsuta*) is a well-known example of an elastic fruit. If the ripe siliqua be touched, its two valves quickly curl up and the seeds are shot out all around. The pod of *Impatiens*, or "touch-me-not," behaves in the same manner.

FIG. 2.—Fern Spore-Case, showing Annulus (enlarged).

FIG. 3.—Legume of Bird's-foot Trefoil after dehiscence, showing the twisted Valves.

FIG. 4.—Fruit of Stork's-Bill (*Erodium cicutarium*), the Carpels still attached to the Carpophore.

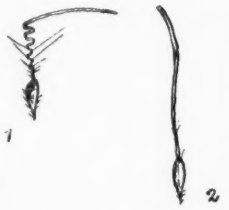

FIG. 5.—Carpel of Erodium. 1. Dry condition. 2. After moistening.

A sharp line can hardly be drawn between hygroscopic movements and those due to turgescence. Of the latter the squirting cucumber furnishes an illustration. When the fruit breaks away from its stalk, the seeds, along with the watery contents, are shot out as from a syringe. Turgescence aids in the dispersion of a number of fungi. The mortar-fungus (*Sphærobolus*) projects its sporangium very much in the way a shell is thrown from a mortar. The globular sporangium retained by the outer membrane of the peridium is pressed from behind, till the tension suddenly ruptures the membrane and the sporangium is forcibly expelled. The rose of Jericho, a small annual found in sandy places in Syria, has the curious habit of curling itself up into a ball; the rootlets become detached from the dry earth, and the plant is rolled along the

ground by the wind. On reaching a moist spot the plant unfolds, its pods dehisce, and the seeds are sown. From this remarkable habit *Anastatica* has been called the "resurrection plant." Placed in a basin of water it at once expands. Anastatica belongs to the order Cruciferæ, but an Australian grass (*Simplifex*) and a Brazilian club-moss possess the same curious wandering habit. From the examples now given it will be seen how widespread is the employment of hygroscopic agency throughout the vegetable kingdom wherever the distribution of seeds or other reproductive bodies is in question. With the exception of the wind, no agency is more in requisition for the dissemination of plant-germs. But notwithstanding this, hygroscopic agency seems to play only a subordinate *rôle* in the distribution of plants. We have but to consider how limited is the range of this force to see that the hygroscopic property is of value chiefly in conjunction with other and more efficacious agencies.

THE LIME.

By Geo. Paxton.

"Above waves wide the linden tree:
With humming bees the air is thrilled."
Mrs. Howitt.

THE lime or linden tree (*Tilia europæa*) deserves to be held in much respect by all botanists, if for no other reason than that the great father of botany, Linnæus, derived his name from it.

Independent of all associations, however, the lime is much esteemed for its own sake; it grows to a very large, handsome tree, and in favourable situations lives to an old age. A fine lime has been called "one of the most imposing specimens of the vegetable kingdom."

This tree used to be the favourite for avenues—indeed, there are few old English parks, or European cities, that cannot boast of their avenues of limes; lately, however, it has fallen into disfavour, either on account of its shedding its leaves so early in autumn or because a less formal style of landscape gardening is now the fashion.

The lime is indigenous to the middle and north of Europe, and is supposed to have been introduced to our island by the Romans. It is quite common, all the varieties having long since been naturalized. It grows generally with a straight stem (fluted in old trees), has smooth bark (Fig. 1) and dense foliage; it is a very quick free grower, and stands transplanting exceedingly well, even when of good size.

The tree grows to a height of from seventy to one hundred feet with a girth often over twenty feet, and is less suited to stand the smoke of towns than the plane, elm, and some others.

The leaves, which usually appear in May, are heart-shaped, lop-sided, and beautifully toothed along their margins. The flowers, small and of a greenish colour, are generally borne three or four together on a curious leaf-like bract; they have a sweet perfume and overflow with honey. The seeds or fruit succeeding are small spherical capsules, which, however, seldom ripen in this country (Fig. 2).

One great peculiarity of the lime is the mass of twigs or "adventitious" branches which often surround the bole, and which give the tree a grace and beauty quite its own. In some avenues these twigs are quite a feature; in spring their red-tinted points look like bunches of coral, which give place to the tender green of the opening leaves. These at this season hang vertically downwards, and are more gracefully tapered towards the apex than later, when they increase in breadth. Two other peculiarities of this tree are the density of its foliage and the immense quantity of sweet-smelling honey-producing flowers which it bears; it consequently receives the industrious attention of the bee—the honey being of a pale colour and excellent quality. On the Continent the lime is much grown for its shade; indeed, even in this country we know of fewer greater pleasures than to spend the long hours of a hot July day reclining in the grateful shade of a large lime, drinking in the sweet odour and listening to the hum of the bees sounding though its branches.

In the middle ages "divine honours" were sometimes paid to this tree. Pliny tells of its "great repute" and "thousand uses." Shields (more important in those days than now) made of its wood were said to deaden the blow of a weapon better than those of any other kind of wood. The bark was a common writing material. Evelyn mentions that a book written on the inner bark of the lime "was brought to the Count of St. Amant, Governor of Arras, 1662, for which was given eight thousand ducats by the Emperor." Alas! there are no such emperors now.

The wood is of a pale yellow or white colour, close grained, soft, light, and smooth, and not readily attacked by insects. It cuts with great ease, and admits of much sharpness in details, and is consequently much used by the carver.

Many of the fine carvings in Windsor Castle, Trinity College Library, Cambridge, and Chatsworth House, are of this wood. It is also used by cabinet makers, piano

Fig. 1.—Bark of the Lime Tree.

makers, and for toys, boxes, and the like. One of the most important uses of the lime, however, in the North of Europe is that of supplying material for making ropes and mats. These mats are made from the tough but flexible inner bark or bast of the tree, and are much used in garden work; indeed, as many as fourteen million of them,

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each about two yards square, are annually imported into Great Britain, chiefly from Archangel.

During the struggles of the Swiss and Flemish to recover their liberty it was their custom to plant a lime tree on the field of every battle they had gained. Some of these

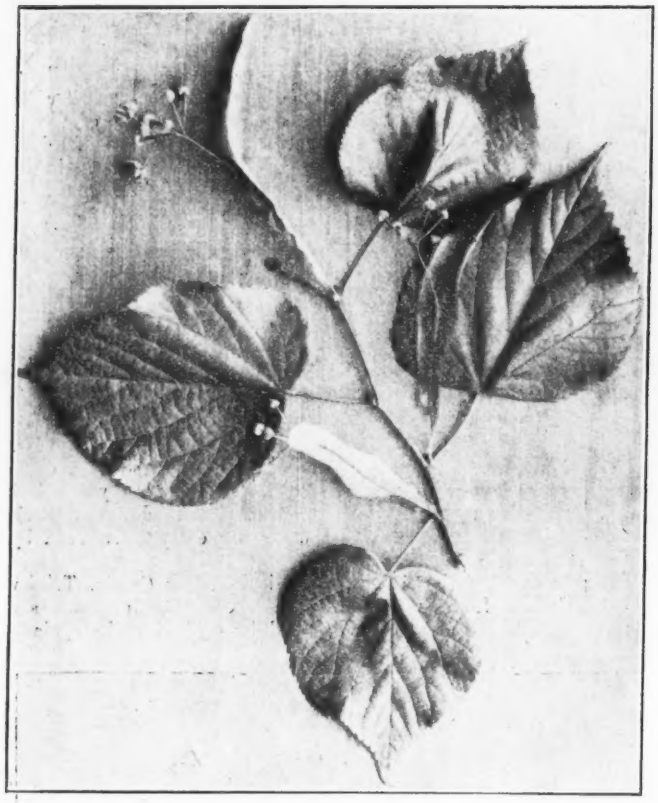

Fig. 2.—Leaves and Seeds of the Lime Tree.

still remain, and have been the subjects of many ballads. One planted at Fribourg in 1476 was standing in 1831, and then measured, according to Loudoun, twenty-three feet nine inches in circumference. Another, near the same place, supposed to be nearly a thousand years old, has a trunk thirty-six feet in girth. A famous tree at Neustadt, in Würtemberg, with a stem nine feet in diameter, has given that town the name of Neustadt *an der Grossen Linden*. At Reinhardtsbrun a lime in vigorous health measured, in 1895, twenty-five feet nine inches five feet from the ground, and has a clear bole of fifteen feet.

Autumn brings new grace to the lime as the foliage turns to yellow—in some years clear as the green of spring, but, alas! even more fleeting. It is to be regretted that this tree is one of the first to lose its leaves; indeed, almost before we have time to realize our brief summer we see them begin to fall. In spring or early summer the lime is at its best, and it is evidently to that time Mrs. Browning refers when she pays it this graceful tribute:—

"Here a linden tree stood, bright'ning
All adown its silver rind;
For, as some trees draw the lightning,
So this tree, unto my mind,
Drew to earth the blessed sunshine
From the sky where it was shrined."

ENGLISH COINS.—II.

By G. F. Hill, M.A.

THE effect of the Norman Conquest on the English coinage is almost imperceptible, and any change that took place was apparently for the worse. Under William I. and II. (whose coins have to be dealt with together, as no satisfactory distinction between the two monarchs has been arrived at) the number of types is numerous, and the facing bust of the king (Fig. 1: PILLEM REX ANGLOR; reverse, MAN ON CANTVLBI, a Canterbury penny) now begins to be very common. The silver of these coins is of about the same fineness as that of our coins of the present time. From this time the style of the coinage deteriorates rapidly, until, under Stephen, it reaches its lowest point. The coins of this period are, however, interesting for the reason that, besides Stephen and Matilda, several other persons who were conspicuous in these troubled days are represented by coins. Thus we have coins of Eustace and William, sons of Stephen; of Henry de Blois, Bishop of Winchester, and Stephen's illegitimate brother (Fig. 2: HEN[RIC]VS EPC; reverse, [STEP]HANVS REX); of Robert, Earl of Gloucester, the illegitimate son of Henry I.; and of Roger, Earl of Warwick.

On his accession Henry II. found the coinage in a bad state. During his reign some uniformity was brought into the system, the number of types being simplified and a single superintendent being appointed who was responsible for the whole of the coinage. In 1180 an important issue took place, which consisted of what are known as "short-cross pennies," from the double or voided cross not reaching to the edge of the coin, which is the uniform type of the reverse. These coins all bear Henry's name, although they were in part issued in the reigns of Richard I. (Fig. 3: HENRICVS REX; reverse, STIVENE ON LVN, a London penny) and of John. Neither Richard nor John struck English coins with his own name. The short-cross pennies lasted until 1247 or 1248, when, to prevent the too prevalent practice of clipping the coins, the cross was lengthened. This was not the only innovation made in this reign.

In 1257 an attempt was made to introduce a gold coinage, which had been inaugurated five years before by the coining of the first "florin" in Florence. Henry's gold pennies (each worth twenty silver pennies) were not a success. They are excessively rare. The probability is that being of pure gold they were speedily melted down (Fig. 6: HENRIC REX III; reverse, WILLEM ON LVNDE). Another innovation was the placing of III, or TERCI(us), after the king's name. Curiously, this very sensible reform was not followed out by later kings, and the numerals do not appear again after the king's name until the time of Henry VII. The only lasting change made by Henry III. was the introduction of three pellets in the angles of the cross; these pellets occur constantly until the time of Henry VII., and only finally disappear under James I. It has been suggested that they gave rise to the three balls adopted by money-lenders as their sign.

The coins of the first three Edwards are difficult to distinguish. By this time the voided cross has given place

to the cross pattée, *i.e.*, broadening towards the ends. (Fig. 4: EDW R ANGL DNS HYB, *i.e.*, Dominus Hyberniæ; reverse, CIVITAS DVREME. On this coin the mint-mark, a small cross moline at the beginning of the legend, is noticeable as being the sign used by Bishop Beck, who filled the see of Durham from 1283 to 1310.) Edward I. and Edward II. limited their actual coinage to the silver penny and its half and quarter; but the third king of this name made a far-reaching change by the introduction of a splendid series of gold coins, as well as by striking fourpenny and twopenny pieces (groats and half-groats) in silver. In 1353 Edward struck gold florins worth six shillings, with half-florins and quarter-florins. These, however, being valued too high in terms of silver, failed, and were withdrawn. The "noble," of six shillings and eight pence (the origin of our lawyer's fee), issued in 1344, was a greater success, though, perhaps, a less beautiful coin. Fig. 8 represents the florin, of which only two specimens are known; the king is seated, facing, a leopard on each side of the throne, fleur-de-lys strewn over the field. On the reverse is the motto: IHC (*i.e.*, Jesus) TRANSIENS PER MEDIVM ILLORVM IBAT. The legend (Luke iv. 30) was supposed to be a charm against thieves, and thus appropriate to the coinage. The half-florin and quarter-florin bore heraldic types (a leopard bearing a banner with the arms of France and England, and a lion standing on a "cap of maintenance," the field strewn with lys). The noble is represented by Fig. 9. Here the king is shown in a ship, with sword and shield bearing the royal arms. The reverse, like that of the florin, is purely decorative, and bears the same motto (with or without the addition of AVTEM after the first word). The origin of the obverse type is uncertain, the only plausible suggestion being that it has reference to the naval victory of Sluys, won by the English four years before these coins were issued. The half-noble was similar in type to the noble, but the quarter bore the shield of arms alone; the half with the motto, DOMINE NE IN FVRORE TVO ARGVAS ME, the quarter with EXALTABITUR IN GLORIA.

In 1351 the penny was fixed at eighteen grains, and groats and half-groats were issued. The groat bore two circles of inscription on the reverse, the outer containing the motto, POSVI DEVM ADIVTOREM MEVM, the inner the mint name (in the case of Fig. 5, CIVITAS LONDON). Before the Treaty of Bretigny, in 1360, Edward calls himself King of France on his coins; from 1360 to 1369 he is Lord of Aquitaine (DNS HYB & AQT. Lord of Ireland and Aquitaine, on Fig. 5); after 1369, when the treaty was broken, he again claims the title of King of France. The half-groats are very similar to the groats, and the pennies are still of the type introduced by Edward I. The coinage which was thus established by Edward III. remained materially unaltered for more than a century, and his gold coinage was so fine that it was largely exported abroad. Under the impression that the wealth of a country was measured by the amount of gold it possessed, the English legislated time after time against the exportation of gold coin, but to no effect. Not only were the coins themselves exported, but imitations of all kinds were made on the Continent, varying only in legend or in some small heraldic detail. The next change of importance in the English coinage was due to Edward IV. In 1465 this king issued a new noble worth ten shillings, and a new coin worth six shillings and eight pence to fill the place of the old noble, which had risen in value. These nobles (which were also called "royals" or "ryals") differ from the old coins in having a rose on the side of the ship, and a rose on a sun in the centre of the reverse; a banner with E also flies from the poop of the vessel (Fig. 12). The half-noble is similar, but the quarter bears on the obverse the shield alone, with E, a rose, a sun, and a lys around it. The rose on these coins is, of course, the white rose of Edward's family, while the sun is explained by the story that before the battle of Mortimer's Cross, in 1460, Edward's victory was portended to him by the appearance in the heavens of three suns (mock suns?). The angel, or angel-noble, was so called from the type of the obverse, which was the archangel Michael subduing Satan (Fig. 7). On the reverse was a ship, carrying a cross between E and a rose, and on its side a shield. The motto was a lame hexameter: PER CRVCEM TVAM SALVA NOS XPE (*i.e.*, CHRISTE) REDEMPTOR. The angelet, or half-angel, is similar in type to the angel itself. As in the case of Edward III.'s coins, a great number of the coins of Edward IV., especially the ryals, circulated and were imitated abroad; specimens exist with the countermark of foreign States, such as Dantzic, upon them.

The accession of the Tudors may be said to mark the beginning of a new era in the English coinage. The execution of the pieces is in every way worthy of the young Renaissance, and the coinage from Henry VII. to Elizabeth has never been surpassed in England for decorative beauty and magnificence. Henry VII. introduced the sovereign, so called from the representation of the full-length figure of the king (Fig. 16). On the reverse were the royal arms in the centre of the Tudor rose. This fine piece, which weighed two hundred and forty grains (our present sovereign weighs one hundred and twenty-three and a quarter grains), was worth twenty shillings of the time, or two ryals. Henry also issued a ryal from which the rose was absent on the obverse, while the reverse is fully occupied by the Tudor rose with a shield bearing three lys in its centre. In silver, Henry VII. introduced an important coin, the shilling, weighing one hundred and forty-four grains, and equivalent to twelve pennies. On these pieces (Fig. 10) the number (VII or SEPTIM) is once more added to the king's name, and the bust appears in profile, being no longer a merely conventional representation but a real portrait. While most of the pennies are of the usual kind, it is interesting to note the recurrence on some of them of the sovereign type. The coinage continued to improve under Henry VIII., and coin was still exported from England in large quantities, since gold was rated at a higher value abroad than in this country. To prevent this it was proclaimed in November, 1526, that the sovereign should be current at twenty-two shillings and six pence, the angel-noble at seven shillings and six pence, and the other denominations proportionately. New coins were also issued, the most interesting being that which was known from its type (the George and Dragon) as the George noble (Fig. 14). We have also at this time the new gold denominations of the crown, of five shillings, and its half, and the quarter-angel. The silver coinage offers several points of interest. One of the counts in the indictment against Wolsey was that "of his pompous and presumptuous mind he hath enterprised to join and imprint the cardinal's hat under your arms in your coin of groats, made at your city of York, which like deed hath not yet been seen to have been done by any subject within your realm before this time." It should be borne in mind that it had long been the custom for bishops to place their mark on pennies issued by their authority (compare No. 4); but it would seem that Wolsey had ventured to place his mark and initials on the larger coins issued, at York, by the king's and not by his own authority. Several groats and half-groats exist with T W to right and left of the shield of arms, and the cardinal's hat beneath it. From the time of Henry VIII. the shield in some form or other is present on almost all English

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coins. The cross, which had been the chief feature of the English coinage since the Conquest, was first omitted on the shillings of Henry VIII.

The interest of Edward VI.'s coinage lies chiefly in his silver. In this metal he issued crowns, half-crowns, and sixpences. The sixpence, like the shilling, bore a crowned bust, sometimes in profile to the right, sometimes facing; the crown and half-crown bore the king on horseback to the right. Two great practical improvements in the English coinage are to be imputed to Edward VI.—the introduction of dates and values on the coinage, although this is limited at first to a few denominations.

We may pass over the coinage of Mary with a mention of the fact that, after her marriage with Philip II. of Spain, she struck half-crowns with the head of Philip on the reverse, and shillings with her own and Philip's heads confronted (Fig. 18). This type inspired the well-known couplet in Hudibras:

> "Still amorous, and fond, and billing,
> Like Philip and Mary on a shilling."

The coinage of Elizabeth is exceedingly plentiful. Besides adding some new smaller denominations, she made various material alterations in the coinage. The new denominations were the threepence, three halfpence, and three farthings. We illustrate here only the halfpenny (Fig. 11, with the Tudor portcullis) and farthing (Fig. 13, with ELIZABETHA R in a monogram, crowned). The most important innovation of Elizabeth's in the process of coinage to be chronicled is the introduction of the use of the mill.

Until the sixteenth century coins had been struck with a hammer; this slow method was now partly superseded, at first in Germany, then in other countries, by a machine put in motion by hydraulic wheels, and hence known as a mill. The use of the word "milling" to describe the roughened edge of modern coins is inaccurate, and the milled coins of Elizabeth and her successors can only be distinguished from the hammered by the greater neatness of the workmanship (Fig. 19 is a milled half-sovereign of Elizabeth). For some reason the new process was only employed for a limited number of coins, and the hammer was not finally superseded by the mill until the time of Charles II. (1662).

To the time of Henry VIII. the English coinage had maintained a very high level of purity, which accounts for the constant exportation of English money to countries where the coinage had become debased. For the sake of a little immediate profit, and perhaps to prevent this constant exportation, Henry issued gold and silver coins of a base quality, and his example was followed by Edward VI. and Mary. Elizabeth, however, was wise enough to see the badness of the system, and called in all the base coin. She seems, however, to have thought it good enough for Ireland, for it was passed over to that country.

The issue of so many small denominations in Elizabeth's reign is evidence of the general desire for small change. There exist patterns made under Elizabeth for copper coins, but it was not until the time of James I. that an official copper coinage was issued. Meanwhile the want was partly supplied by the issue of private tokens. These were given in change, and when, say, twenty-four farthing tokens of the same kind had been collected, the person who issued them would redeem them by payment of sixpence in coin of the realm. A private token coinage seems to have existed as early as the fifteenth century, but the nature of the tokens then used is involved in some obscurity. It is not, in fact, often certain whether the known leaden pieces of the fifteenth and sixteenth centuries were tokens or merely counters used for reckoning. Between 1590 and 1600 Elizabeth granted permission to the city of Bristol to issue city tokens, all private tokens being called in. A specimen issued early in the seventeenth century is illustrated here (Fig. 15: obverse, C B, for Civitas Bristol; reverse, the city arms).

The coinage of Scotland, which commenced in the reign of David I. (about 1124), was at first an imitation of the English coinage. It can hardly be said to have been important before the time of David II. (1329-1371), who imitated the gold nobles of Edward III., and also issued groats and half-groats, in addition to the smaller denominations which had been introduced by his predecessors. The groat here illustrated (Fig. 17: obverse, DAVID DEI GRAtia REX SCOTORVM; reverse, DomiNus PROTECTOR MeuS & LIBerATOR MeuS; in inner circle, VILLA EDINBVRGH) was struck at Edinburgh. The stars which here take the place of the balls in the English coins are characteristic of Scottish silver coinage from William the Lion to Robert II. Like the Continental coinage of these times, that of Scotland—which was in close relation with France—was of a very inferior quality, and caused many complaints in England. The influence of France may also be seen in the first Scottish gold pieces of an original character, viz., those issued by Robert III. These are the St. Andrew crowns or lions, with a crowned shield bearing a lion rampant on the obverse, and a figure of St. Andrew on the reverse (Fig. 24: XPC, *i.e.*, Christus, REGNAT XPC VINCIT XPC IMPerAt). In style and legend these coins remind us of the French coins of the period. We must pass over the numerous and various issues of the successors of Robert III., mentioning only the fine "bonnet-piece" of James V. (Fig. 20: reverse, HONOR REGIS IVDICIVM DILIGIT), to the time of Mary Queen of Scots, whose portrait may be seen on the testoon of 1561 here illustrated (Fig. 21: reverse, S' LVVM FAC POPVLVM TVVM DOMINE, arms of France half effaced by those of Scotland), which was struck after the death of Mary's first husband, Francis. In spite of the union of the crowns, the coinage of Scotland remained distinct from that of England until the union in the reign of Anne.

The Irish coinage may be dismissed very briefly. None is known between the time of Æthelred II. and that of John, who, both as Governor of the island and as King of England, struck a series of coins. His regal coins have triangles on both sides; on the one containing the bust, on the other the sun, moon, and stars (Fig. 22: obverse, IOHANNES REX; reverse, ROBERD ON DiVE, a Dublin penny). More interesting, however, than the coins of John himself are the silver "Patrick farthings," reading PATRICII on one side, and DE DVNO or CRAGF on the other. These were struck at Downpatrick and Carrickfergus by the Earl of Ulster and Governor of Ireland, John de Curcy (whose name occurs on some in place of the mint name), between 1181 and 1189. The Irish coinage of Edward IV. was very extensive, but of no particular interest. The Irish harp first appears on the coins of Henry VIII., which are of very poor metal. Elizabeth's Irish silver was also base; but this ruler introduced a coinage of actual copper pence (Fig. 23: obverse, ELIZABETH D.' G.' AN.' FR.' ET HIBER.' RE', with E R at the sides of the shield; reverse, POSVI DEV' ADIVTOREM MEV.', with the harp crowned and date 1601), and halfpence of similar types. No gold was ever struck for Ireland.

As rulers of various parts of France, the English sovereigns, from Henry II. to Henry VI., struck considerable series of Anglo-Gallic coins. Among the most interesting are those issued by Edward the Black Prince,

one of whose *pavillons* (struck at Bordeaux) is all that we have space to illustrate here (Fig. 25: obverse, EDwardus PrimOGeNituS REGis ANGLiæ PriNCepS Aquitaniæ; reverse, DomiNus AdIVTOr & ProTECTOr MEus & In IPsO SPerAVIT COR MEVM. Burdigalæ).

APPRECIATION OF MUSICAL PITCH.

By Dr. J. G. McPHERSON, F.R.S.E., *late Mathematical Examiner in the University of St. Andrew.*

DR. McKENDRICK, the Professor of Physiology in the University of Glasgow, lately brought before the Royal Society of Edinburgh a remarkable case of the early appreciation of musical pitch. His attention was drawn to the wonderfully accurate ear of John Baptist Toner, a boy of four and a half years of age. From the photograph shown us we could see that he was a smart and intelligent boy; he seems quite healthy and cheerful. His parents are both young and musical. His father excels on the organ and piano, and has studied musical harmony; his mother sings well, and loves music; but no other member of the family, collateral or ancestral, is known to be of a musical turn of mind.

John used to watch his father playing on the piano, and when two years of age would by himself finger the keys. Shortly before Professor McKendrick saw the boy, John had been told by his father the names of the notes on the piano. The exact notes left a lasting impression on the boy's mind. He acquired the names of the white keys in two or three minutes, and that over the whole keyboard. Next day he picked up the black keys in the same short space of time. The impressions seemed photographed on his memory, for when any note, white or black, was struck, he would instantly name it, though his back was turned to the instrument.

Professor McKendrick examined the boy in his father's house, so as not to disturb him by a change of associations. The professor struck notes here and there on the piano, when the boy could not see the keyboard, and John named them as soon as he heard the sound, without any hesitation or mistake. Not only so, but when the professor struck any two notes at random on the keyboard, the boy named them accurately at once. The boy even went the length of naming three notes when simultaneously struck by the professor on any part of the keyboard, commencing at the highest note and coming downwards in the naming of them. The boy's attitude during the experiment was leaning over the sofa at the other side of the room from where the piano stood, with his back to the instrument; and it was the professor who struck the keys. The piano was at concert pitch. Dozens of experiments accurately answered satisfied the professor that the boy had a remarkably acute ear for appreciating the different notes.

It was the concert pitch notes that were fixed in John's memory; for when, on another occasion, he tested the boy's ear with a set of Koenig's forks, he gave different names to the notes. These forks are lower than concert pitch, and the boy would give the name of the note corresponding to the concert pitch note. When a fork at concert pitch was struck, the boy would at once name the exact note with which his ear had been familiar. The notes seemed to be as accurately marked in his mind as the words of a verse of poetry. The boy accurately named the sounds as they corresponded to his standard. Thus he had acquired a standard of pitch fixed by his father's concert piano, and he remains true to that standard in all circumstances. If the professor named a note within the compass of the child's voice, John at once sang it correctly at concert pitch, as immediately after tested by striking the corresponding key on the piano.

John was then taken to the house of the professor to have his skill tested on the piano and organ there. The Bechstein piano and American organ were both at concert pitch. The boy was at first a little diverted from the necessary concentration of mind by the changed associations; but after a time he settled down and answered with perfect accuracy all the notes and groups of two and three notes simultaneously sounded on these instruments, although his back was turned to them.

This remarkable case is quite different from the tonic sol-fa system. In the latter the keynote is given three times, and the pupil is then expected to sing to words or to the syllable *la* any part in a psalm or hymn tune in the tonic sol-fa notation not seen before; and many thousands of children can do this easily. But there the keynote is given—quite a different test from that given to John Toner. This boy had no key or reference note given to him to guide and steady him in his search after particular notes. In his case the pitch is appreciated directly, and where he has had no musical training whatever. He had the standard and main key fixed in his mind. Of course for two years and a half the boy had been frequently touching the keys of the piano and listening to the corresponding sound; that was, so far, an education in the variety of notes. But it was only a short time before the professor saw him that he was told by his father the names of the white notes and the black notes. Moreover, the boy detects the notes within the whole range of the piano.

Professor McKendrick noticed the peculiarity in the boy's discrimination of the three notes simultaneously sounded. John always mentioned first the one highest in pitch, and he seemed to "feel about," as it were, for the other notes; but he invariably named them accurately within a quarter of a minute. The severe strain of three notes told on him, for after a time he would make mistakes, as if his little brain had not been able to retain the three impressions with sufficient distinctness to fix them accurately. When fresh, however, he invariably answered with correctness. The lowest note of the piano was struck by the professor and the boy could not name it correctly; but it was ascertained that that note was out of tune. The boy asked his father to name the notes in the same way, and laughed when mistakes were made, naturally wondering why his father could not do what to him was so very easy.

Dr. McKendrick directed attention to the importance of this case in connection with the question of "tonal fusion and analytic powers." In some cases a quick "ear" can, after long training, discriminate the several notes struck in this way, but many skilful musicians are deficient in the faculty. "One can hardly resist the conclusion," he says, "that it is a gift dependent on the delicacy of the ear and the part of the brain that receives auditory impressions, and that each note of a given instrument has, to such an individual, an undefinable quality or colour by which it is identified."

Professor Edgren, of Stockholm, gives some remarkable instances of the marvellous ease with which young children acquire the discrimination and expression of sounds before they can speak. Reyer brought over a nine-months-old child which accurately repeated the notes sounded on the piano. Stumpf's child sang the scales exactly at the age of fourteen months. The son of a compositor, Dvorak, of Prague, sang, when only a year old, the "Fantinitza-marsch," with its nurse. When eighteen months old it sang the melodies of its father, which he accompanied on the piano. But these curious cases are quite different from the marvellous discrimination of young John Toner.

XUM

WAVES.—VIII.

CAPILLARY WAVES.

(With information upon Breaking and Spraying, and upon the Use of Oil at Sea.)

By Vaughan Cornish, M.Sc.

A SHIP on her course leaves a wave track behind, whilst in front there is scarcely any visible disturbance except the foaming surge at the bow. It is otherwise with a small body moving slowly through the water, which makes the principal disturbance in front. If, when walking slowly by the edge of a pond, one trails his walking stick in the water, little ship-waves of the familiar pattern follow in its wake, but in front of the stick there is a novel appearance not seen with the ship. This is an arrow-head pattern of wavelets or capillary waves, such as is shown in Fig. 1, the pattern

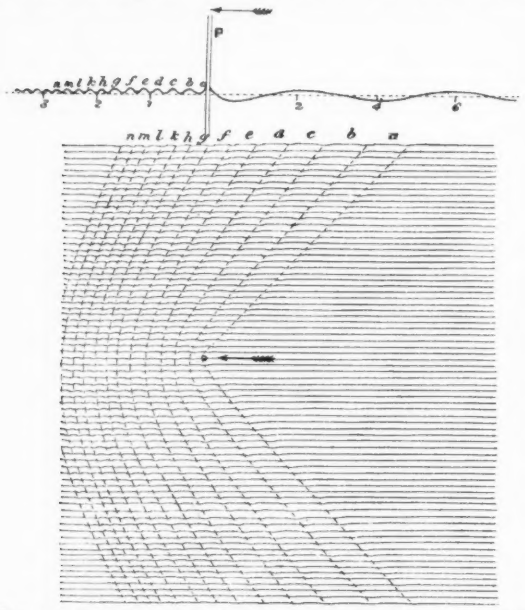

Fig. 1.—The Wavelet Pattern, after Scott Russel. (The Section shows also the Waves on the lee side which are omitted from the Plan.)

moving as a whole through the water, preserving its position relatively to the stick. The pattern is seen even better with a fishing line, especially if the line be kept nearly vertical by a weight: the ship waves behind are not so conspicuous with the smaller body, but the pattern of wavelets in front is better defined. The appearance is seen equally well when fishing from a river bank or from a boat slowly drifting on a smooth sea. All that is necessary is that there should be a slow relative motion of, say, a half to one mile per hour between the obstacle and the water; dozens of ridges can then be counted in front of the fishing line. When the motion is more rapid the pattern closes up, and at the same time the angle of the arrow-head becomes sharper. On slowing down again the arrow-head flattens out, until at a very slow speed, about nine inches per second, the obstacle is preceded and followed by one or two nearly straight parallel ridges separated by intervals of about two-thirds of an inch. This phase is difficult to catch, for if the motion becomes ever so little slower the ridges vanish altogether, the surface of the water being smooth and unwrinkled. About nine inches per second is the lowest velocity possible for a wave of water, and there is one definite wave-length, about two-thirds of an inch, corresponding to this speed. As soon, however, as the speed of the moving body is decreased, two sets of undulations of different wave-length accompany the body, and it therefore appears that for any speed greater than nine inches per second there are two wave-lengths, one greater and one less than two-thirds of an inch. The latter are the wavelets or capillary waves (which Lord Kelvin calls ripples) which form the fore part of the visible wave pattern of a small moving body. Those furthest in front are the shortest, the wave-length increasing as we go backwards through the pattern. These wavelets which run by capillarity move quicker the shorter their wave-length. Waves which run by gravitation move quicker the longer their wave-length. The wave of minimum velocity is controlled equally by the two forces of gravitation and capillarity. Wavelets a little shorter are mainly controlled by capillarity; waves a little longer are mainly controlled by gravity; and if the wave-length is much shorter or much greater than two-thirds of an inch, the one or the other force has complete control. Clerk Maxwell treats the case of a small body moving slowly through water in the following manner. In front of the body the relative velocity of the water and the body varies from V, the velocity of the body, where the fluid is at rest, to zero at the cutwater, where the fluid is forced to move with the body. The waves produced by the body roll away from the cutwater until they reach distances from it at which the relative velocity of the body and the fluid is equal to the several velocities corresponding to the wave-length of the several disturbances. Nearest the body is the wave of minimum velocity. Now what does theory indicate that there should be in front of this, where the relative velocity of the water and the body is greater? *Theoretically* there is a double series of undulations—capillary waves and gravitation waves, the former getting shorter, the latter getting longer, the further they are in front of the body. *Practically* we do not notice the gravitation waves in front, because they are too flat, whereas the little wrinklings of the capillary waves are rendered conspicuous by the play of light and shadow upon their steep sides. The wave of minimum velocity diverges least on either side of the path of the moving body, and at a distance on either side it is the most conspicuous part of the pattern. When the body moves quickly, even though it be small, the amplitude of the disturbances is so much increased that the gravitation wave nearest the body becomes steep enough to be conspicuous. This corresponds to the great bow wave of a steamer. Now these gravitation waves drop their energy behind them, as was explained in the article upon the force of the waves, so that the bow wave makes a group of waves behind it, and these are the waves which follow in the track of the ship although originating in front. Directly in the wake of the ship or moving body they appear as a procession of waves following the ship, each keeping its place relatively to the ship. Their outer border on either side of the ship's path is a series of short billows, stepped back one behind the other *en échelon*, as described in the article upon ship waves. Each line of the capillary waves, on the contrary, presents an unbroken front—a continuous arrow-head. This, I suppose, indicates that the energy of the capillary waves does not lose itself in the depths of the water, but keeps in the skin of the liquid: that is to say, the surface film of capillary thickness. If this be so, the form of the wave front of the capillary waves created by a moving body is readily explained. Let us think for a moment of the pattern formed by the drops falling from the blade of an oar when swung back slowly

for a stroke. The wavelets from the falling drops ring out thus (Fig. 2), and the dotted line shows the arrow-head wave-front which would be produced if the disturbance were continuous instead of intermittent.

The arrow-head pattern of diminishing wavelets is a decorative tracery of singular delicacy worth knowing for its beauty, apart even from its scientific interest. The pattern can be seen on the up-stream side of every pebble which raises a wave in a brook, and on the lee side of every small wave raised by the wind on a calm sea, or on a river, lake, or pond. In front of the breast of a duck, when swimming quietly, the broad pattern is visible; and the little ducklings show it almost better, for they cannot swim fast enough to obliterate the pattern. Those insects from whose feet the water shrinks so that they stand in little holes, make an arrow-headed track when they dart about on the surface of a pond.

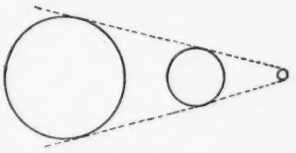

FIG. 2.—The Arrow-Head.

Capillary waves are also formed by other means than those which give the arrow-headed pattern, as, for instance, when a catspaw of wind suddenly darkens the surface of still water, covering it with fairly uniform wavelets, the wrinkled surface smoothing itself once more the moment the gust has passed.

An exquisitely fine pattern of stationary wavelets is seen on the water in a finger-glass when the wetted finger is drawn round the rim so as to cause the glass to vibrate and emit a musical note. The vibrating prongs of a tuning-fork in the same way will produce minute wavelets, which are finer in pattern the higher the note. A special device for showing capillary waves was recently exhibited by Professor Boys at the Royal Institution. A circular glass dish with vertical sides is placed upon a whirling table, and the surface of the whirling water is touched with the point of a needle. The arrow-head takes the form shown in Fig. 3, the wavelets vanishing towards the centre where the velocity is less than that of the slowest wave. Anything which diminishes the tightness of the skin of the water will enable the wave pattern to extend nearer to the centre, for when the surface is not so taut, less force is needed to wrinkle it and the corresponding velocity is less. A little soap added to the water has this effect. The skin of alcohol is not so tight as the skin of water, and if the basin be filled with alcohol instead of water and the vessel be started whirling, the capillary wave pattern appears sooner than with water, and the wavelets are longer from crest to crest. The same is the case with wavelets in mercury, for although mercury has a tight skin the liquid is so much heavier than water that the force required to propagate a wave is provided by a slower motion of the liquid. Capillary waves on liquid metals such as mercury (or molten aluminium) are very beautiful owing to the perfection of the surface reflection.

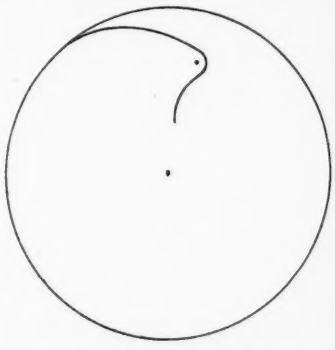

FIG. 3.—The Arrow-Head in a Whirling Dish.

The force called "capillary," which gives a liquid a tight skin, requiring an appreciable force to wrinkle or ruffle it, is due to the strong attraction exercised between the neighbouring particles of a body, and between those parts of different bodies which are so close that, to our senses, they appear in actual contact. At very small distances attraction can be very much stronger than is accounted for by the *law* of gravitation—the law which states that attraction is proportional to the square of the nearness. This law appears to hold good from the greatest distances down to, say, the hundredth or the thousandth of an inch, but at much closer quarters the law no longer holds. Not that any new agency necessarily comes into play, but that the law of its action is changed. Perhaps, as Lord Kelvin has pointed out, if we could locate each molecule we should be able to account for the increased attraction at close quarters, simply by the arrangement of the discontinuous matter. A spot may be so hemmed in by the contiguous molecules that their attraction is far greater there than that of all the distant parts of the body, however large it may be. It is this which constitutes the strength of materials.

Obviously, the conditions with regard to such short-distance actions must change abruptly at the surface of a body. Indeed, the surface of a solid body is the boundary of a universe, on the two sides of which are two different laws of being. At present, however, we are concerned with the surface of a liquid. If Fig. 4 represent a vessel containing a liquid and its own vapour, the horizontal line representing the surface of separation, and if we consider the attractions upon a particle C of all other particles which are very near to it; we see, in the first place, that as there are fewer particles above than below (the vapour being less dense than the liquid), it will require work to carry the particle C into the upper part of the vessel. This is a familiar fact; energy is taken up, *e.g.*, in the form of heat, when a liquid is made to evaporate. Secondly, to pull C down into the depths of the liquid will similarly require the supply of external energy, because the attraction of all particles below the dotted line is as nothing compared with the attraction of the neighbouring particles in the thin film above the dotted line. On the whole, therefore, there is a resultant force along the surface of the liquid, which makes the surface behave something like a stretched sheet of india-rubber, for it always tries to shrink so as to make itself as small as possible. It requires force to wrinkle it because wrinkling increases the extent of surface; and, if the compulsion be withdrawn, the crests fall smartly down, and the troughs jump nimbly up; inertia carries crest and trough past the middle line, vibration goes on with diminishing amplitude, and presently the surface comes to rest. This is the vibration of a capillary wave, surface tension wave, or ripple.

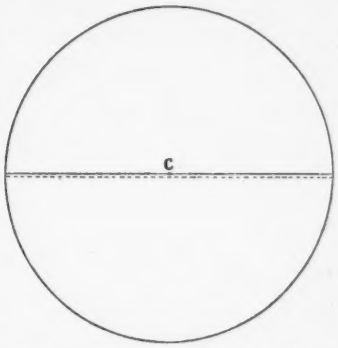

FIG. 4.—The Surface of a Liquid.

It is the shrinking of the surface which makes liquids tend to form spherical drops, the sphere being the figure

of smallest surface, and therefore the proper equilibrium figure of a liquid. In practice one seldom sees a perfectly spherical drop, because gravitation towards the earth tends to pull it out of shape, the more so the larger the drop. Thus a large hanging drop has the shape shown in Fig. 5 —very much that of an india-rubber bag filled with water. If one gently taps a bough on which the dewdrops hang, each one trembles, the larger ones more slowly than the little ones, for the total shrinking force of the elastic skin is proportional to the area of the surface; but the attraction of the earth depends upon the mass of the drop, which is proportional to the volume. The quivering of a soap-film is more quickly brought to rest owing to the deadening action of the air, which presses upon it from both sides.

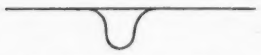

FIG. 5.—A Pendent Drop.

The elastic skin which capillarity provides accounts for the regularly repeating form of a water jet which has received some slight lateral displacement when issuing from a nozzle. As Lord Rayleigh points out in describing his beautiful researches upon liquid jets, the recurrent form of the jet is due to vibrations of the fluid column about the figure of equilibrium, superimposed upon a general progressive motion. Since the phase of vibration depends upon the time elapsed it is always the same at the same point in space. The distance between consecutive corresponding points of the recurrent figure (*the wave-length*) is proportional to the velocity. In fact, the recurrent broadening and narrowing of a jet in which at the outset some slight lateral disturbance has occurred, is comparable to the series of stationary crests and hollows to leeward of an obstacle in a shallow stream, but caused by capillarity, not by gravity. When a water jet breaks up into drops, owing to capillarity the drops strike against one another; and such is the elasticity of the skin of a water drop that, instead of amalgamating at collision, the drops fly apart almost as if they were billiard balls, and to this is due the scattering of the jet. Anything which helps the drops to cohere at collision diminishes the scattering. This is the effect produced by electrifying the spray, when the drops, cohering, fall in a steady, rattling shower—like the rain in a thunderstorm, says Professor Boys, whose "happy thoughts" flow as readily as those of Mr. Burnand himself.

The pressure of wind and eddy upon either side of the higher billows in a rising sea causes the tops of the ridges to burst into spray. The least additional resistance on the lee side makes these forced waves break more violently, the masses of broken water which are flung bodily forward being dangerous to vessels, especially the smaller craft. This danger may be, to a great extent, avoided by diminishing the capillary shrinking of the sea's surface by the use of oil. When a drop of oil is placed upon water there are three surfaces—the water-air surface, the oil-air surface, and the oil-water surface. To these three surfaces there correspond three stretching forces. If no two of these be greater than the third the oil remains in a lens-shaped drop, as is the case with the oily drops (which should not occur) upon hot soup, hot water having a much smaller surface tension than cold. In the case of cold water the tension of the water-air surface is greater than the sum of the tensions of the other two surfaces, and the oil cannot remain in a thick drop, but is dragged out into an inconceivably thin film, and spreads with surprising rapidity over a great space of water. So much of the sea as is covered with oil has no longer a powerfully capillary surface, but a feebly contractile oil surface, and there is no longer the same liability of breaking and spraying. The waves are as high as ever, but smoothly crested and comparatively harmless. Not much oil is required,* for there is no object in having a thick film; half a gallon an hour is said to be sufficient for a large ship. It is best applied from a canvas bag punctured in one or two places and hung over the side. When lying-to in a heavy sea the bag should be hung out to windward. When drifting under shortened sail the oil may be fed to leeward, so that the ship drifts into quiet water. When a vessel is in tow, oil fed over the stern of the tug is very useful in preventing the sea from breaking against the convoy.

The surface tension and the density of water being known, the force required to wrinkle the surface can be calculated. The pressure of the air being known, the velocity can be calculated which must be given to the lower layers of the air in order that their motion should wrinkle the surface, nothing like friction (*i.e.*, the mutual engagement of rough surfaces) being supposed to occur. This requisite wind velocity is calculated by Lord Kelvin to be 12·8 knots, which, of course, is very much greater than that which is found by observation to suffice for rippling the surface of the sea. It appears, therefore, that a part of the work of raising waves is due to something of the nature of friction. This fluid friction is supposed to be due to diffusion. When air and water are in contact, air is always dissolving in water and water is always evaporating into air. In a closed vessel the water soon saturates the air-space with moisture, and the water soon absorbs as much air as it can hold. This does not mean, however, that nothing goes on afterwards; there is a continual interchange, but evaporation and absorption proceeding at equal rates no further change is observable. So it is with the air and the sea: molecules of the gases of air are continually dashing into the water and remain there—for a time at least—and molecules of water are continually flying up into the air. When the air is blowing strongly over the surface of the water each particle of air as it dashes into the sea helps to impel the water forward; the driving wind not only presses forcibly upon the water but drags at it almost as a harrow, digging with its teeth, scratches the soil along.

AN EXPEDITION TO DISCOVER HOW CORAL ISLANDS GROW.

By E. W. RICHARDSON.

FIFTEEN years ago Darwin, finding surface investigation and dredging insufficient to determine with certainty the origin and genesis of coral atolls, expressed in a letter to Alexander Agassiz the wish that some rich man would have borings made in some of the Pacific and Indian atolls, and bring home cores from a depth of five hundred or six hundred feet for examination. For nine years this idea lay dormant in the minds of scientific men, but six years ago it took shape, and a committee of leading geologists and biologists was formed by the British Association to carry it out. Professor Bonney was appointed chairman and Professor Sollas secretary to this committee. The British Association appealed to the Royal Society, which readily supported the scheme. A large sum was voted from the Government Grant Committee, and another by the Royal Society from its own funds. Professor Anderson Stuart, of Sydney, N.S.W., has given great help, and it was through his efforts that the Colonial Government was

* A shoal of sprats makes a smooth patch of oily water which tells the fishermen of their whereabouts.

induced to lend drill and steam plant to the value of two thousand five hundred pounds. The New South Wales Government also supplied skilled workmen, and contributes towards the wages of those in charge of the machinery.

After some five years' preliminary preparation and hard organizing work, an expedition to carry out Darwin's wish, and to discover by boring the origin of a coral atoll, was formed. The expedition is in charge of Professor Sollas, who is well known as having devoted special attention to coral formations. The other members of the expedition are Mr. John Stanley Gardiner, B.A., whose work as a biologist is considered of great promise, and Mr. Charles Hedley, of the Australian Museum, who, besides being a naturalist, is an artist, and will make all the drawings and sketches for the expedition.

The Government have placed H.M.S. *Penguin* at the disposal of the expedition, for the purpose of carrying the *personnel* and plant from Sydney to the scene of operations and back. The *Penguin* started on May 1st, and next month will probably be bringing the members of the expedition back. The island chosen for investigation is Funafuti, the largest isle of the atoll of that name, which forms one of the group of the Ellice Islands. These coral isles are situated in latitude 9° south, longitude 180°, and almost due north of Fiji. Funafuti is a typical atoll, being a chain of thirty-five islets encircling a large central lagoon about ten miles long by five wide. The chief island—and that on which the expedition is located—is about four miles long by half a mile wide, and it is nowhere higher than from eight to nine feet above the sea level. The island, which is under British protection, is covered with cocoanut trees, and supports a peaceful population of four hundred natives, nominally Christian.

Professor Sollas' instructions are simplicity itself; he is "to investigate a coral reef by sounding and boring," and is to do so with a mind quite unbiassed as to the various rival theories of coral-reef formation. The drill which does the boring is faced with black diamonds, which will cut through anything. The diameter of the drill is four inches. Seeing that the coral polype has never been recorded as living at a greater depth than ninety feet, it will only be necessary to bore to a depth of six hundred feet, and if that depth be reached the chief object of the expedition will have been attained. At the same time it is an open secret that Professor Sollas intends to go as far down as one thousand feet, if possible, and thus solve beyond a doubt the point to be cleared up.

Science Notes.

MR. T. RUDDIMAN JOHNSTON has projected a most interesting and instructive aid to the study of geography in the shape of a huge terrestrial globe, having a diameter of eighty-four feet, and showing the earth's surface on a scale of about eight miles to the inch. Every geographical feature of any importance will be found on the proposed globe, several sections of which have been already constructed under Mr. Johnston's patent, and these may be seen at 24, Pall Mall.

A correspondent writes: "I have heard that the 'perch' land measure of sixteen and a half feet, derived from *pertica* (Lat.), 'a rod,' had its origin in the long goads used in former times to goad on the ploughing oxen, which subsequently came to be used as land measures. Can any of your readers inform me if there is good authority for this statement?"

From investigating the cases in which death caused by electricity has occurred, whether by the accidental passage through the body of a powerful current used in industrial processes, or by the designed passage in cases of execution by electricity, the conclusion is reached that usually death by electricity is due to the excitement of the nervous centres, producing stoppage of respiration and syncope. Brown-Séquard and D'Arsonval are of this opinion. In many cases where artificial respiration is employed, a man apparently killed by electricity or lightning can be resuscitated. A man struck by lightning should be treated like one apparently drowned.

Notices of Books.

Mars. By Percival Lowell. (Longmans.) 12s. 6d. "A steady atmosphere is essential to the study of planetary detail, size of instrument being a secondary matter." So Mr. Lowell begins his book. "With regard to work on the planets, the important point about an observatory is not so much what is its lens as what is its location." These are his closing words, and it is to his realization in his observing station of the condition which he presents in these two sentences, coupled with the steady determination to study Mars as long and as continuously as it was possible, that won him the remarkable success which he has recorded in the most interesting and striking volume now before us.

Mr. Lowell's "Mars" marks an epoch in the study of our planetary neighbour. There can be no doubt of that. As certainly as Mr. Green's true and beautiful designs, in 1877, established a record then, not since surpassed in their own line—as certainly as the discovery of the canal system by Prof. Schiaparelli marked a little later a new period—so Mr. Lowell's work advances us further still; and the marvellous, the almost incredible result is presented to us that, from actual observation of a planet some forty or fifty millions of miles away, we have a strong *primâ facie* case made out for the recognition of the actual handiwork of intelligent beings. Of mere speculation and surmise we have, of course, had, in the past, volumes by the score. This is different. It would, of course, be absurd to speak as if Mr. Lowell's presentment of his case amounted to a mathematical proof; that cannot be expected. But he certainly makes it what we may fairly term "reasonably probable" that in the "canals" of Mars we have the evidence of the work of skilled and trained intelligences—of engineers and mathematicians, in fact—and it is not too much to say that this is an achievement of the most astonishing kind.

The book is written in a style both bright and clear, and we feel sure that our readers will be grateful for being induced to read it. To our own mind the most valuable part is the clear demonstration of the progress of the effects of season on Mars. In the chapter on "Atmosphere," however, a reliance is placed on differences of measurements of diameter of too minute a character to merit much confidence until very fully confirmed by independent observations in other oppositions. But, as a whole, the book stands as a remarkable record of a most successful attempt to extend our exploration of Mars.

British Sea Birds. By Charles Dixon. (Bliss, Sands, & Foster.) Illustrated. 10s. 6d. Mr. Dixon is an energetic and constant writer on ornithology. The subject of this volume has so often, and especially of late, been discussed and written about, that there really seems nothing fresh to say. Indeed, it is difficult to find a use for this book.

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It is not arranged in a way to be of any use as a book of reference, and is scarcely popular enough to be of general interest. We must therefore take it as a book merely of passing interest to bird lovers, and as this it makes very pleasant reading, and brings back to our minds many a day spent with the birds and the sea.

James Clerk Maxwell and Modern Physics. By R. T. Glazebrook, F.R.S. (Cassell.) "Century Science Series." 3s. 6d. Mr. Glazebrook, in his preface to this short memoir of Clerk Maxwell and his work, expresses the fear that his attempt to explain to non-mathematical readers the problems attacked by the great investigator, "without the aid of symbols is almost foredoomed to failure." In this we cannot agree; for it is by no means impossible, while avoiding the exact reasoning expressible only by mathematical symbols, to describe in words at least the nature of the problems attacked, and the conclusions to which they lead. Unfortunately, this attempt has somewhat overtaxed Mr. Glazebrook's skill. The earlier part of the book, dealing with the life of Clerk Maxwell, is brightly written and intensely interesting. The anxiety of the child to know the "particular go" of everything around him made his manner somewhat eccentric, and gained for him among his schoolfellows the nickname "Dafty." This eccentricity developed later into a genius for mathematics, in which study Clerk Maxwell easily eclipsed all his schoolfellows. And in 1846, when he was barely fifteen years of age, his genius was displayed in a communication to the Royal Society of Edinburgh, "On the Description of Oval Curves, and those having a Plurality of Foci." It is interesting to observe that mathematical ability, like musical genius, is almost always of early development. It was thus with Lord Kelvin, whose jubilee has just been celebrated.

J. Clerk Maxwell

From *James Clerk Maxwell and Modern Physics.*

An unfortunate misprint occurs over and over again in Mr. Glazebrook's book, wherever the ratio of the specific heats of gases is touched on. It is when the number 1·33 is given as the theoretical ratio between the specific heat of an ideal gas at constant volume and at constant pressure, instead of the correct number, 1·66. And this misprint has the result of rendering obscure the whole explanation of Clerk Maxwell's reasoning. It is especially to be regretted that confusion is thus introduced into a subject which it is most difficult to expound in popular language.

Clerk Maxwell must have been an ideal teacher for those who possessed the will and the power to learn. The secret of the success in teaching at Cambridge is contained in a sentence of his introductory lecture: "The student who uses home-made apparatus, which is always going wrong, often learns more than one who has the use of carefully adjusted instruments, to which he is apt to trust, and which he dares not take to pieces."

The biographical part of Mr. Glazebrook's book ends with chapter vi., and chapters vii. to x. are devoted to an exposition of Maxwell's researches. The account of his experiments on vision is clear and essentially accurate; but it is unfortunately otherwise with his account of Maxwell's share in the development of the kinetic theory of gases. For example, while the conclusion is correctly drawn that the specific heats of all gases are inversely proportional to their densities, Mr. Glazebrook adds: "This is the law discovered experimentally by Dulong and Petit to be approximately true of a large number of substances." To anyone who knows the subject, Mr. Glazebrook's meaning, though obscurely expressed, is clear enough. He would say that the specific heats of elements are inversely proportional to their atomic weights, and that these may be taken (though with many exceptions) as proportional to the densities of the elements in the gaseous state. But, as it stands, a much fuller explanation is required to make the passage intelligible. The account of Prof. Bolzmann's theorem of degrees of freedom, on page 139, is quite unintelligible; nevertheless it is not impossible to express its main features in popular language.

It is very difficult, too, to derive any clear idea of Clerk Maxwell's theories of electricity and magnetism from Mr. Glazebrook's words; and yet the main features might have been expressed so as to be understood partially by the half-scientific public.

It is with regret that we write in this deprecatory vein, for the task which Mr. Glazebrook has set himself is a praiseworthy one, and it is a pity that his book cannot be unreservedly praised.

Artistic and Scientific Taxidermy and Modelling. By Montagu Browne, F.G.S., F.Z.S. (A. & C. Black.) Illustrated. 21s. Some years ago Mr. Browne brought out a very useful book on the subject dealt with in the present volume, which is, however, much more advanced and elaborate. With this book in his possession the collector should be able to preserve and mount, either artistically or scientifically, any specimen which he may possess or obtain. Mr. Browne treats, in the most clear and practical way, of the ways of collecting, skinning, preserving, modelling, casting, mounting, and grouping of mammals, birds, insects, fish, and reptiles, and of the tools and preservatives most useful for these purposes, besides the methods of modelling and casting of rocks, trees, and flowers. When we add that the author has had long personal experience as curator of a large museum, we are sure that no further commendation on our part is needed. That this is the best and most useful book on the subject ever published is undeniable.

BOOKS RECEIVED.

The Story of Electricity. By J. Munro. (Newnes.) Illustrated. 1s.

Observations de l' Eclipse Totale du Soleil du 16 Avril, 1893. Par M. H. Deslandres. (Paris: Gauthier-Villars et Fils.)

Modern Optical Instruments. By Henry Orford. (Whittaker & Co.) Illustrated.

Things New and Old. Book VII. By H. O. Arnold-Forster. (Cassell.) Illustrated.

Results of Meteorological, Magnetical, and Solar Observations at Stonyhurst College. By Rev. W. Sidgreaves, S.J., F.R.A.S.

The Old Light and the New. By Wm. Ackroyd, F.I.C. (Chapman & Hall.) Illustrated. 1s. 6d.

Physics for Students of Medicine. By Alfred Daniell, M.A., LL.B., D.Sc. (Macmillan.) 4s. 6d.

The Law of the Symmetry of Composite Flowers. By W. W. Strickland. (Malton: R. S. Smithson.) Illustrated.

Text-Book of Zoology. By Dr. J. E. V. Boas. Translated by J. W. Kirkaldy and E. C. Pollard, B.Sc. (Sampson Low, Marston.) Illustrated.

A Geographical History of Mammals. By R. Lydekker, B.A., F.R.S., etc. (Cambridge University Press.) Illustrated. 10s. 6d.

The Evolution of Bird-Song. By Charles A. Witchell. (A. & C. Black.) 5s.

A Concise Handbook of British Birds. By H. K. Swann. (Wheldon & Co.) 3s. 6d.

Rheumatism. By T. J. Maclagan, M.D. Second Edition. (A & C. Black.) 10s. 6d.

Voxometric Revelation. Written and compiled by J. Abner for the Author, A. A. North. (Authors' and Printers' Joint Interest Publishing Co.) Illustrated.

Plants of Manitoba. A Series of Chromolithographs. (Marcus Ward.) 10s. 6d.

The Biological Problem of To-day. By Prof. Dr. Oscar Hertwig. Translated by P. C. Mitchell, M.A. (Heinemann.)

The Universal Law of the Affinities of Atoms. By J. H. Loader. (Chapman & Hall.) 2s. 6d.

Wayside and Woodland Blossoms. Second Series. By Edward Step, F.L.S. (Warne.) Illustrated. 7s. 6d.

What it Costs to be Vaccinated. By Joseph Collinson. (William Reeves.)

Practical Radiography. By H. Snowden Ward, F.R.P.S. (Dawburn & Ward.) Illustrated. 1s. 6d.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

TIDAL WAVES AND THEIR CAUSE.

To the Editors of KNOWLEDGE.

SIRS,—I have long been of the opinion, so well expressed by Mr. Wohlwill in the July Number of KNOWLEDGE, that the usual explanation given of the coincident occurrence of high water at the antipodes is unsatisfactory.

Could not a theory of the tides be formulated more in accordance with the facts and known dynamical laws? In the received theory our earth's solid nucleus is supposed to be completely submerged beneath an exaggerated ideal ocean, in which a tidal wave is supposed to follow continuously in the wake of the moon, without any interruption whatever, this again being followed by another tidal wave in the same hypothetical universal ocean at the antipodes, the two waves always occupying the same relative position to each other and to the moon, and consequently completely and continuously circumnavigating the globe as our satellite apparently does from east to west.

But what are the actual facts? The terrestrial waters only partially cover the solid earth, and are irregularly divided by the two principal masses of the dry land—the continents of the Old and New Worlds—which extend north and south of the Equator almost to the Poles, so as to effectually act as two great barriers to the continuous movement of any tidal wave from east to west in the wake of the moon. The general effect of this alternate exposure of continent and ocean to lunar influence is that vibratory motion of the latter characteristic of the tides, each antipodal oceanic basin oscillating backwards and forwards twice during the time that the moon makes a single uninterrupted apparent revolution round the earth. The real tide caused by the moon is the primary wave that immediately follows that body. This wave, being unable to follow the moon in her entire circuit, ebbs and again flows back upon the terrestrial barriers before-named, which stretch north and south of the Equator, as a secondary tide, whilst the moon pursues her course beneath the horizon. It is easy to see that a primary wave in the Atlantic will flow in the same direction as a secondary wave in the Pacific, and *vice versâ*, so that we may sometimes get a simultaneous production of high water at the antipodes as the effect of the general arrangement of the great continents and oceans.

In a brief letter like this it is, of course, only possible to deal with the problem in a very crude and imperfect manner. But I am certain that if the geographical relations of land and water were to be taken into consideration instead of being totally ignored, a much more correct theory of the mechanism of the tides than the one at present accepted could be constructed upon sound dynamical principles.

Halifax. H. A. COOKSON.

P.S.—Sir R. Ball, in his work on "Time and Tide," tells us that it is still "a moot point whether high water or low water should be represented beneath the moon, supposing the ocean to be vibrating with ideal tides"—which is equivalent to admitting that the theory is very far from being a complete solution of the problem. Mr. Proctor goes even further, and says that "the theory of the tides remains yet to be satisfactorily established;" and that "although the received theory explains the statical equilibrium of a tidal wave, the dynamical conditions of the problem cannot be thus explained."

To the Editors of KNOWLEDGE.

SIRS,—I cannot altogether follow Mr. Wohlwill's argument in the July Number, but I agree with him that Mr. Cornish is inaccurate.

The usual popular explanation that has been handed on from book to book for several generations is to the effect that the moon draws up the water into a heap on the side of the earth nearest to itself, while it pulls the earth away from under the water on the remote side of the earth.

On this hypothesis the sheer direct *lifting* power of the moon causes the tides to arise, and their position would be such that the two opposite high tides would be always in a line with the moon if there were no land to interfere with the free motion of the water. Mr. Cornish seems to have accepted this theory almost in its entirety.

Now, from the mathematical theory of the tides (*see* Airey, Brinkley, Abbot, etc.) we learn that they are produced solely by the *tangential* action of the moon, *i.e.*, tangentially to the earth. This consists in an acceleration (or retardation) of the rotation of the watery shell of the earth acting through alternate quadrants, as the earth, with its oceans, rotates under the moon. Further, it is demonstrated that theoretically (*i.e.*, if there were no obstructing continents) *low water* would be found almost directly in a line with the moon at any given moment.

The whole subject of tide-production is an abstruse one, requiring the higher mathematics for its investigation, and is really incapable, apparently, of being described in homely language. But this does not warrant the use of simple language, if it is to be done at the cost of sheer misstatements of scientific truths.

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There would surely be a great future for the man who will discover a handy, accurate, and intelligible account of the cause of the tides without using mathematical phraseology!

(Rev.) C. ROBINSON, B.A.

Willow Road, Birmingham,
July 1st, 1896.

[*Pace* Mr. Wohlwill and Mr. Robinson, I did not say, either that the earth is pulled away from its *orbit* or that the raising of the water is due to a *direct* lifting power.—V.C.]

To the Editors of KNOWLEDGE.

SIRS,—The subject which is mentioned in the correspondence of the July Number of KNOWLEDGE, the formation of the ocean tides, is one on which we of the general public are sadly in need of fresh instruction and guidance. I have endeavoured, by looking up author after author of those within my reach, to obtain an authoritative explanation of the manner in which the great tides are produced; but I find them discordant one with another, and unsatisfactory or insufficient in themselves. Each explanation is based on one or more of the following ideas or theories, of which the most prevalent is the first one:—

(1) The suction theory. According to it, the moon (and the sun, but for brevity sake I will omit it), having more power over the waters nearest her than over the earth as a whole, draws them up—sucks them up in fact—into a heap under her; the action is described as direct, and is referred to as natural and requiring no elucidation. The authors would seem to have gone back to the old times when we all believed that the "sucker" in the pump drew the water up; and they fail to see that the tidal power of the moon, being almost infinitesimal compared to the earth's gravity force, could raise towards herself in direct opposition to gravity neither a particle of water, nor a grain of sand, nor any portion of matter, small or large.

(2) Closely connected with the "suction" is the "slip" theory. It is used to account for the secondary tide; the solid earth is said to be drawn away from the waters on the side farthest from the moon, and in fact to slip through the water moonwards, leaving a bulge of the ocean behind it. Unfortunately for the theory, the solid earth and the water are held together by a bond many million times stronger than the power which the moon can exert to separate them.

(3) One of my authors rests the explanation solely on the "weight" theory. The difference of the moon's attraction on the various parts of the water *tends* to separate them in the larger portions of the sphere, and to compact them at the quadratures; that tendency asserts itself by change of weight in the water, which results, through gravity, in rising and sinking, *i.e.*, in the tide bulges and depressions.

Two other writers eke out the "suction" by the "weight" theory, and one uses the latter idea as if he believed that light bodies have in themselves a power of ascension. None of them descend to the application of the idea; if they did they would readily perceive its inadequacy to do more than to help slightly the formation of the tide bulges. Our oceans are but a few miles in depth, but, in order to account for a rise of only three feet in their height, a depth of water of between three thousand and four thousand miles would be required.

(4) One—perhaps the greatest of my "authorities"—treats the tides as a case of "perturbation," similar to that to which heavenly bodies, such as the moon and the earth, are subject in their revolutions. But, however true that idea may be in the result, it is impossible to identify the course of action of the ocean, tied down as it is by gravity to the earth, with that of bodies moving freely in space.

(5) A great encyclopædia describes the force originating the phenomenon, but stops short cautiously at its *tendencies*, and omits to trace for us the course of its action, saying, "Thus we see that the tidal forces tend to pull the water towards and away from the moon, and to depress the water at right angles to that direction."

I note that most of the authorities recognize the existence of nothing but "force" in the case; that is to say, an agency like gravity, acting on each molecule of matter. The molar result of the action of "force" on matter, namely, "pressure," is considered only in one of its manifestations, "weight." The idea that the "tidal forces" of the moon acting on the water might produce "pressure" in a direction other than the vertical, does not seem to have been taken up by them. They have set themselves the difficult task of explaining to us the action of "force" on water without the aid of hydrostatics. J. CREAGH.

BILLOWS.

To the Editors of KNOWLEDGE.

SIRS,—From my earliest childhood I have always observed the rhythmic succession of maximum developed waves, with intervals of quiescent water, which I always attributed to the rhythmic gusts in light blows, and to the rhythmic paroxysms of violence always observable in heavy gales.

I have ever been impressed, during storms, with the regularity of this motion in heavy rolling, and have often taken its time, which I always find to be every twenty minutes—that is, three times in every hour; this rhythmic oscillation, with some five, six, or seven seas, then easy steaming. Some call these largest waves "tenth waves," but they are nearer "fiftieth" in such gales.

When the sea rises in tempests, and the exits leading out on deck have to be battened down, the passenger vouchsafed on deck by the captain imagines that the waves are the highest possible; but they are only the highest at that particular time and phase in that particular storm. So the gallant Scoresby thought when he measured what he believed to be the highest billows.

My good friend Captain Atkin, of the Cunard Steamship Company, related his experiences in the heaviest hurricane which he ever met on the North Atlantic some five winters ago, the like of which he does not desire ever again to run into. From his bridge—a coign of vantage not possessed in Scoresby's time—with the steamer in the trough of the sea, he observed the crests of the tremendous surges considerably higher than the top of the funnel, and but little below the masthead. Again, a well-posted American sea captain, lately returned from a passage around the Cape of Good Hope, using Dr. Scoresby's method, measured mountainous billows of the type of Mr. Daniell's realistic and ideal picturing on page 164 of your last issue, on the South Atlantic, from fifty-eight feet up to seventy-two from trough to crest; but he did not get the distance from crest to crest, or their velocity. H. P. CURTIS.

SEA SICKNESS.

To the Editors of KNOWLEDGE.

SIRS,—I followed Mr. Moy's advice recently, and secured a berth lengthwise of the steamer, whereon I lay carefully on my left side, with my head towards the engine room. The cabin was amidship, and the engine room aft, so my

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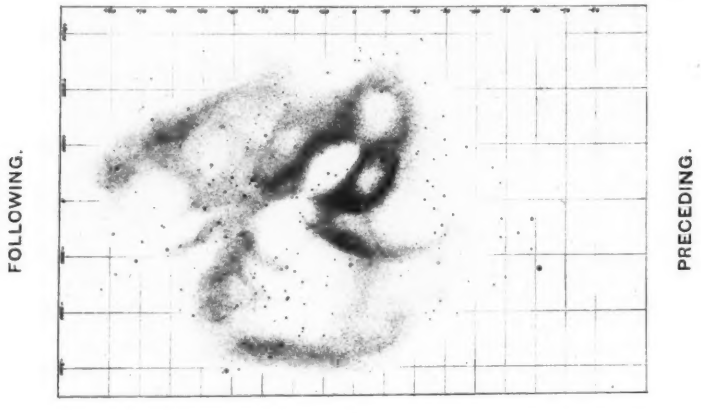
M 8 SAGITTARII. Enlarged from a Photograph by Prof. K. D. NAEGAMVALA, taken May 18-19, 1895, with an exposure of 2 hours 40 minutes.



M 8 SAGITTARII. Reduced to approximately the same scale as the above, from the engraving by Sir JOHN HERSCHEL, Plate I. of the "Cape Observations."

head was towards the stern. I was dreadfully ill that journey.

Returning next day by another steamer I again followed the directions, but on this occasion the cabin was aft and the engine room amidship, so my head was towards the bow. This time I was much better, but there was very little sea on.

As engine rooms vary in position they are no guide, and I want to know which way of the ship is the right one.

A LANDSMAN.

[We have shown our correspondent's letter to Mr. Moy, who says that "A Landsman" appears to prove the correctness of his theory and experiment, which, in Mr. Moy's case, was tried on a paddle steamer, in which the engines and boilers were amidships, and the position of the centre of gravity was therefore clearly amidships. In "A Landsman's" first experiment he appears to have been on a screw steamer, with the engine room well aft. If loaded, the centre of gravity would be a little abaft the centre of the vessel, and the position of his berth would render inoperative the effect arising from longitudinal oscillation; a berth much further forward would have effected his purpose.—EDS. K.]

NOTE ON A PHOTOGRAPH OF THE NEBULA M 8 IN SAGITTARIUS.

By Prof. KAVASJEE D. NAEGAMVALA, M.A., F.R.A.S.

THIS nebula was very carefully examined by Sir John Herschel in the years 1836 and 1837, during his voluntary exile at the Cape of Good Hope. It has been fully described on pages 14-16 of the Cape *Observations*, and a half-page drawing of it has been assigned the place of honour in the plates.

Sir John Herschel describes it in the following words:—

"Its brighter portion may be described as consisting of three pretty distinct streaks or masses of nebula of a milky or resolvable character, arched together at their northern extremities so as to form some resemblance to the arches of an italic letter *m* very obliquely written, and this is the aspect under which it strikes the eye on a cursory view. On closer attention these streaks are seen to be connected and run into each other below (or to the south) by branches and projections of fainter light, and to form three distinct basins, insulating oval spaces—one entirely, the others comparatively dark. Northwards, a great effusion of faint nebula runs out, insulating a larger and more ill-defined basin of great extent and irregular form, which in some measure communicates with the best defined and darker of the three oval spaces already spoken of."

The stars, both of M 8 proper and of the cluster h 3725 just following it, are involved in the nebula, and Herschel has counted and assigned places to one hundred and eighty-six stars, ranging in magnitude from six to sixteen, in the region involved. Almost every one of these stars can be recognized on the photograph taken with an exposure of two hours forty minutes.

The nebulosity, however, impressed on the plate is much more extensive than that portrayed by Herschel, and the star 7 Sagittarii, shown as being absolutely free from any nebulosity in the drawing, is distinctly surrounded by nebulous matter in the photograph. This difference in visually recognizing the extent of the *nebulous* matter may very likely be due not only to the continuous action of the photographic plate, but also to the difference in the focal ratios of the two instruments employed. Sir J. Herschel's reflector was of eighteen and a quarter inches diameter and twenty feet focus, giving a focal ratio of a little over 1:13, while the focal ratio of the reflector employed for photographing was only 1:7·4.

An exposure of about four hours, in my opinion, would involve 7 Sagittarii in the same common nebulous envelope as M 8 and h 3725. This view is further supported by a photograph taken with one hour's exposure with an old portrait combination by Ross of two and a quarter inches diameter and about seven inches back-focus, in which the nebulosity completely extends right beyond 7 Sagittarii.

But the chief point of interest centres in the nucleus of the nebula, which, in the words of Herschel, "is decidedly not stellar, and resembling much more that of the nebula in Andromeda than any other I (Herschel) can call to mind as a term of comparison." Presumably, therefore, he had most carefully observed this nucleus, and delineated it faithfully with his great skill. In the drawing the nucleus is shown decidedly *concave* towards the *following* side, but it is as much clearly *convex* in the photograph.

The photograph taken with an exposure of two hours forty minutes has the stellar images not quite circular; but another, taken with an exposure of one hour thirty minutes, has stellar discs much more perfect, and on it, too, the nucleus is distinctly *convex* towards the *following* side. The photographs are mainly in agreement with Herschel's drawing; but to what cause could be assigned this gross discrepancy in the form of the nucleus is a question on which I cannot presume to enter.

The photographs were taken in the principal focus of a sixteen and a half inches reflector, of one hundred and twenty-two inches focal length.

STOCK-TAKING OF THE VARIABLE STARS.

By Lieut.-Colonel E. E. MARKWICK, F.R.A.S.

THE advance in the discoveries of variable stars, both by photography and direct observation, is proceeding so rapidly that it seems desirable to take stock or count of those very interesting bodies and see how we stand at present. It is evident that the theory or theories of the variable stars must hold an important place in the larger theory of the universe. If we can interpret correctly what is going on in a star or sun, this will be the key to similar phenomena occurring in countless other suns; and hence we are gaining an insight into a part, and an important part, of the interior economy of the universe of worlds.

This was not so in the past. The variable stars (there being then comparatively few known) were looked upon rather as peculiar cases or exceptions, the great multitude of stars being regarded as absolutely unchangeable. But now the number of the variables is so considerable, and the phenomena connected with them, as shown by the spectroscope, are so extremely complicated, that the attention of astronomers is being more and more directed to them.

Some years ago Dr. Gould announced his opinion that "a very large proportion of the fixed stars exhibit fluctuations of brightness"; and although at present, either with photometers or photography, regular variation of less than half a magnitude is exceedingly difficult to prove, still the progress of the optical and mechanical arts may in the future give us the means of detecting with certainty variation so small as the one-tenth of a magnitude.

The study of variable stars, in the matter of variation of light only, does not, like other branches of astronomy, require very elaborate apparatus to detect variation of

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half a magnitude or over. For the brighter stars it would seem that the unassisted eye is still the best photometer. Then from the fifth to the seventh magnitude the binocular or field-glass is a very excellent means of research, while for stars below the seventh magnitude the telescope must be called into use.

Hence this is a study peculiarly applicable to amateurs, many of whom take it up to become practically professional observers. This has been especially the case in America. The writer can speak to the enjoyment and pleasure obtained in such observations, for he has devoted his leisure hours to the variables for the past eleven years.

A photometer provides the means of bringing the images of two stars close together for study and comparison; but the naked eye can do this by a slight movement of the observer's head without the intervention of any lenses or prisms whatever. Again, the binocular commands a large field, and one or more comparison stars are generally included in it; but it also can, if necessary, be swiftly shifted a few degrees right or left, up or down, and a good estimate of relative brightness of two stars formed. In the telescope we are of necessity tied down to one field alone, and for the brighter stages of a variable star it is not always possible to include in it a suitable comparison star.

The meridian photometer of Pickering is of course, theoretically, a more accurate method of comparing the light of two stars; and so should photography be also. When, however, we come to practice, it is easy to see that the instrumental or photographic results are by no means in rigid agreement, *inter se*. Hence we are of opinion that, for some time yet, the ordinary method of direct eye estimates of brightness will hold its own against the other methods.

Photography, as a record, is more or less perfect, and we see how fruitful the study of plates has already become when we read of Mrs. Fleming announcing a batch of fourteen new long-period variables at once.*

In 1886, Mr. Gore published a very interesting paper on variable stars,† and with a slight modification we shall adopt his classification; one hundred and eighty-seven stars were then dealt with.

Taking now the second catalogue of variable stars by Dr. Chandler, together with the revised supplement to the same, which brings our information up to June, 1895, we find three hundred and forty-three variables contained therein. Those discovered since that publication are not here referred to.

The variables may be divided into the following classes:

Class I. Temporary or new stars (eleven).

Class II. Stars with large variations and periods of one hundred days and upwards in length (two hundred and thirty-eight).

Class III. Irregularly variable stars (thirty-two).

Class IV. Variable stars with periods of less than one hundred days (forty-seven).

Class V. Algol-type stars (sixteen).

This catalogue of Chandler's is quite a mine of information on the subject.

Going into a few statistics:—As to Class I., the text-books give two stars which are not included in the eleven, probably on account of insufficient data as to position, etc., viz., the star of B.C. 134 (Hipparchus), and that of A.D. 329, in Aquila. So that the number of temporary stars is just thirteen, which, however, has been augmented since by photographic discoveries.

Class II. comprises the great bulk of the variables. An analysis of the two hundred and thirty-eight stars is given in the following table:—*

Length of Period. Days.	No. of Stars.	Variation in Magnitudes.		
		Greatest.	Least.	Mean.
100 to 120	Nil.	—	—	—
120 „ 145	6	6·1	1·2	3·3
145 „ 175	12	6·0	1·5	4·1
175 „ 200	8	5·4	1·6	3·9
200 „ 225	16	6·7	2 3	4·5
225 „ 250	9	6·5	1·0	4·2
250 „ 275	17	7·0	2·3	4·7
275 „ 300	17	7·0	1·8	4 9
300 „ 325	18	7·2	1·8	5·0
325 „ 350	14	7·8	1·2	4·5
350 „ 375	23	7·4	0·9	4·5
375 „ 400	14	6·8	1·3	4·0
400 „ 425	7	9·5	4·7	6·5
425 „ 450	6	8·1	2·5	5·3
450 „ 475	2	6·2	4 6	5·4
475 „ 500	3	4·1	2·5	3·4
500 „ 600	2	3·1	2·8	2·9
600 „ 700	1	—	—	6·8
Over 700	1	—	—	3·8

It will be seen that up to three hundred and twenty-five days there is a marked tendency for the amount or amplitude of variation to increase with the period. This is not so marked from three hundred and twenty-five days to four hundred and seventy-five, although the variation is still considerable. Higher than this the stars are so few in number that the "mean" is not reliable.

Class III., the "irregulars," may be further subdivided into (*a*) those with small variation, (*b*) considerable variation. We thus get:—

	No. of Stars.	Variation.		
		Greatest.	Least.	Mean.
III. (*a*)	20	1·9	0·4	1·0
III. (*b*)	12	7·2	1·9	4·1

Class IV., or short-period variables of less than one hundred days' period, comprises forty-seven stars, analysed as under:—

Length of Period. Days.	No. of Stars.	Variation.		
		Greatest.	Least.	Mean.
0 to 5	11	1·4	0·5	1 0
5 „ 10	16	2·0	0·7	1·1
10 „ 15	2	1·1	0·8	1·0
15 „ 20	3	1·7	0·8	1·3
20 „ 25	1	—	—	1 1
25 „ 30	1	—	—	2·4
30 „ 35	1	—	—	3·4
35 „ 40	2	1·8	1·5	1·7
40 „ 50	2	2·1	0·7	1·4
50 „ 75	4	4·3	1·6	2·5
75 „ 100	1	—	—	1·2

Here again, as in Class II., can be seen a tendency for the amount of variation to increase with the period. One deduction, however, from the table is plain: the range or amplitude of variation in these short-period variables is much less than in the case of Class II., the stars of long period.

Class V. comprises the rare Algol stars—only sixteen in number up to the date of the catalogue. The star with the longest period and greatest amount of variation is S Cancri, viz., 9d. 11h. 37m. and 1·6 magnitude; that

* *Harvard College Observatory Circular*, No. 6.

† *Journal of Liverpool Astronomical Society*, Vol. V., p. 23.

* The author regrets that an error as to the total number of stars has crept into this table, and also the table of Class IV., which he is unable to correct in time for press owing to not having access to his original notes. The general conclusions are, however, in no way affected.

at the other extreme is S Antliæ, viz., 0d. 7h. 46m. and 0·6 magnitude.

As to the distribution of the variables in space, as we know them at present, one hundred and eighty-one are in the northern hemisphere, and one hundred and sixty-two in the southern. We have prepared maps of these on an equal surface projection, and on the same scale as the maps in Proctor's "Universe of Stars." The Milky Way is shown. In the northern hemisphere eighty-seven stars are either on or near the Milky Way, showing an evident connection with it. As the area of the Milky Way in the northern hemisphere is certainly not so much as one-fifth of the hemisphere, it is evident that far more variable stars are on it than should be, if they were evenly distributed over the sky. There seems a paucity of stars in the hours 9 to 14 of R.A.

In the southern hemisphere there is a "nest" of variables in about 16h. of R.A. and 20° declination, and another (evidently connected with the Milky Way) in 10h. R.A. and declination 60°. These aggregations might be due to the fact of a search of an investigator being confined to a limited part of the sky. On the whole the connection with the Milky Way does not seem so marked as in the northern hemisphere. In the hours 1 to 4 of R.A. there is a paucity of stars, and there is not a single star in hour 11.*

Now comes the plain question, what is the meaning of the variable stars? This is a hard nut to crack, and Class I., or the temporary stars, is perhaps the hardest of all to understand. Scientific men seem doubtful at present whether the outburst of light which we call a new star is due to an increase of heat and light in the star itself, or to a collision between the star and another body, whether solid or meteoric.

The various papers published in the scientific periodicals on the new star T Aurigæ, which appeared in 1892, show what different ideas prevail on the subject, and we quote some of them briefly. The Rev. W. Sidgreaves and Prof. Campbell think the phenomena of this star were produced in a single body. Dr. Huggins believes in Klinkerfue's and Wilsing's theory, viz.: two bodies travelling in opposite directions swing round, and tidal disturbances come in which bring about eruptions of the hotter layers of matter from the interior. Miss Clerke agrees with this. Mr. Maunder put forward the theory that a long and dense stream of meteors was travelling towards a star and rushed into or just grazed it. Mr. Ranyard explained the Nova as a small star moving away from us through a nebula which was moving towards us. Vogel thinks the Nova was produced by an encounter of a heavenly body with several others. Prof. Pickering suggests the phenomena as due to an outbreak of eruptive prominences on an enormous scale.

I do not mean to say that these are the views of the above-named at the present time, for our knowledge is evidently in a transitory stage, and views modify themselves rapidly as fresh discoveries are made. Enough has been said to show that it is a difficult matter to explain a new star.

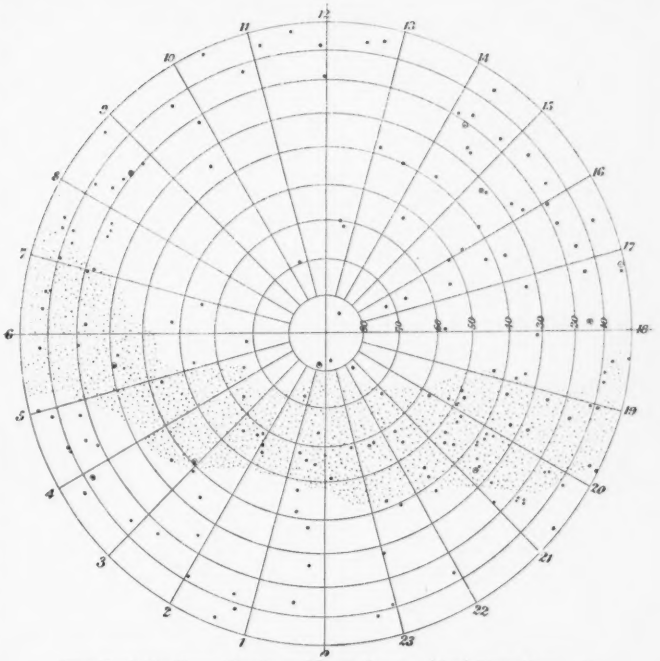
Then come the long-period variables. Here it is presumed the variation in light must take place in the sun itself, and Dr. Brester has recently enounced in this journal what appears to be a satisfactory theory to account for the increase and decrease in light.

* In reproduction the maps have been reduced one-half linear.

The question of the interpretation of shift in the lines of a star's spectrum is discussed by Dr. Brester, and he does not think it can always be attributed to motion in the line of sight. Such shift may be produced by changes of pressure, temperature, chemical combinations, etc. In fact, the conditions under which gases, etc., exist in celestial bodies are so utterly different from what we can arrange in our laboratories, that it is necessary to be very cautious in interpreting a spectrum. It is, however, plain that motion in line of sight, when really existing, can be easily detected in the spectroscope, for Vogel observed Venus, and found that the observed (spectroscopic) velocity in line of sight only differed from the calculated velocity by 0·4 English miles per second.

The irregularly variable stars may, in many cases, be taken to be peculiar cases of Class II., but perhaps more difficult to explain.

It seems that the change in short-period variables like



The Variable Stars, Northern Hemisphere. Algol Stars thus: ☉

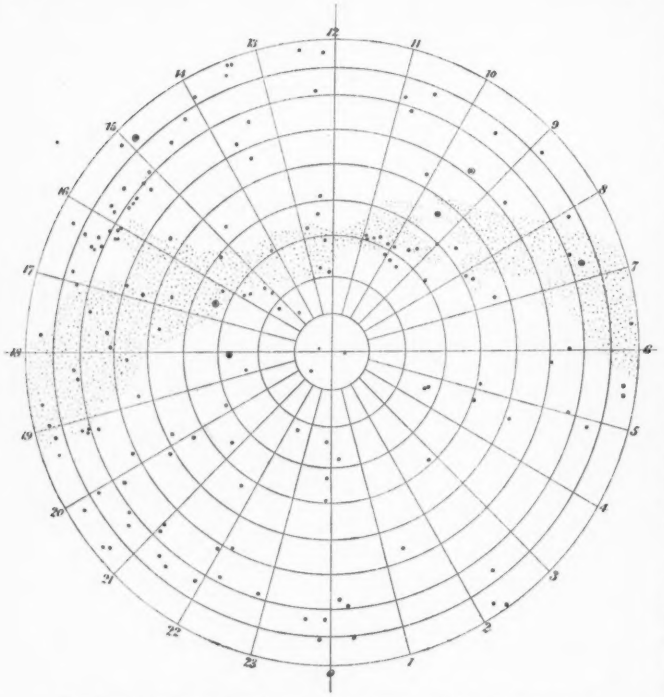
X or W Sagittarii or S Sagittæ is due to an orbital cause: a dark companion revolving round a bright central star, or *vice versâ*. But it is difficult to account for the *gradual* change in the light all through the period. The extreme regularity with which such stars go through hundreds and thousands of their phases is a well-marked feature. Other stars, like β Lyræ, are different. Vogel thinks the spectrum of β Lyræ is due to transiting of two bodies of unequal brilliancy in an elliptical orbit whose plane is in line of sight. When the less brilliant body occults the brighter, the principal minimum takes place. The equal maxima "occur when the bodies are side by side, at right angles to the line of sight. The second minimum occurs when the brighter body occults the darker." This theory might, perhaps, also cover a star like W Sagittarii, if the components are of nearly equal size and brilliancy.

Lastly come the Algol variables, about which much has been written. Vogel's theory of an opaque satellite revolving round the bright star in the plane of sight, and

periodically cutting off a part of the star's light, seems to account for the principal features of the phenomenon—viz., a sudden diminution of light followed by a rapid rise, more especially as the actual motion is revealed. But it does not explain all. Repeated observation has shown that the brightness of the star does not remain constant after the minimum has been passed; the old idea must be given up that the light curve can be represented by a straight horizontal line, with a sudden depression and then a recontinuation horizontally.

Dunèr considers Y Cygni to consist of two equally large and bright companions and that the line of apsides revolves.

A remarkable announcement has been recently made that the spectrum of Altair (hitherto free from all suspicion of variation) shows peculiarities from which it is inferred that the star is a "spectroscopic triple," the two secondary bodies being dark as compared with the principal. Prof. Pickering foreshadowed this result some time before in a paper on the discovery of double stars by means of their spectra.



The Variable Stars, Southern Hemisphere. Algol Stars thus: ⊙

Enough has been said to show how incomplete is our knowledge of the variable stars—yet that knowledge is advancing with such rapid strides that we may hope to obtain clearer views as time goes on; and when the problem of variable stars is solved a great step will be made towards that knowledge of the constitution of the heavens which Sir W. Herschel, Proctor, and others have so earnestly sought after.

Since the above was written the work of discovery of variable stars goes on apace, and Prof. Pickering announces ten new ones in *Harvard College Observatory Circular*, No. 7, of which one was previously noted by the writer. The Professor also finds that S Antliæ is not of the Algol type, but that its light is continually changing after the manner of δ Cephei and η Aquilæ.

OUR FUR PRODUCERS.—IV.

FUR-SEALS.

By R. LYDEKKER, B.A.Cantab., F.R.S.

PROBABLY there are still to be found persons who believe that "sealskin" is the product of our common British seals; and it is, therefore, well to state at once that this is not the case. It is true that the fur of an ordinary seal has much the same appearance as that of a fur-seal when in its natural state, but the former lacks the fine, soft, woolly under-fur which alone constitutes the sealskin of commerce. To remove the upper fur, the skin was formerly always, and still is frequently, shaved on the lower surface; and as the long hairs are more deeply emplanted than is the under-fur, their roots are cut away by this process, and the hairs themselves can then be brushed out. This process is technically known as "pulling"; and visitors to the Natural History Museum at South Kensington may see, in one of the bays on the left side of the entrance-hall, sealskin before and after it has been subjected to this process. After the removal of the long hairs the sealskin is dyed and curled, and is then ready for use. Seals that yield commercial sealskin differ from ordinary or true seals (*Phocidæ*) in many points—notably in the retention of small external ears, and in the circumstance that, when on land, the hind flippers are bent forwards beneath the body, instead of being stretched straight out behind. It must not, however, be supposed that all the eared seals (as the members of the family *Otariidæ* are best termed) yield commercial sealskin. On the contrary, many have only the long hairs without any of the woolly under-fur, and are consequently spoken of as hair-seals, in contradistinction to fur-seals. Not the least curious feature in connection with this difference is that hair-seals and fur-seals are found inhabiting the same districts, showing that the presence of under-fur does not depend by any means on the latitude of the habitat of the animals.

Although the price of the individual pelts is comparatively small, the enormous number brought into the market renders sealskin probably the most important item in the whole fur trade; and when it is stated that up to 1889 upwards of one hundred thousand fur-seals were killed annually on the Prybiloffs alone, while in 1874 about four and a half million individuals were computed to visit those islands, some faint idea may be obtained of the magnitude and importance of the trade. Human greed has, however, done its best to ruin this trade by indiscriminate and reckless slaughter; and from many parts of the world where fur-seals formerly swarmed they have now been more or less completely exterminated.

The habits of the fur-seals, and the numbers in which they formerly resorted to their "rookeries" during the breeding season, have been so frequently described that it will be quite unnecessary to allude to them further in the present article; and it will accordingly suffice to notice the species of most importance in the fur trade, with some remarks on the number and value of the pelts annually obtained.

Foremost among these is the northern sea-bear, or Alaska fur-seal (*Otaria ursina*), characterized externally by

its short face, with a nearly straight profile, and the relatively weak dentition. The habitat of this seal is the North Pacific, where it ranges on the Asiatic coast as far south as the latitude of Tokio. The chief localities of the seals in Behring Sea are the Prybiloff and Commander Groups, the former constituting the head-quarters of the East Behring herd and the latter of the western herd. In the Commander Group, Copper and Behring Islands are the seal resorts; while in the Prybiloffs, St. George and St. Paul are the chief islands for seals. These latter were formerly leased to the Alaska Commercial Company. According to the terms of the lease, not more than 100,000 seals were to be killed annually on these islands; and this number was, as already stated, reached in 1889. Since that date the limit has, however, been very much reduced, the numbers killed in 1890 being 25,701; in 1891, 14,406; in 1892, 7509; and in 1894, 15,033. No females are allowed to be killed on the islands; and this prohibition has resulted in such a diminution in the number of males that probably five-sixths or more of the fur-seals now existing in the Northern Pacific are females.* Indeed, to such an extent have the males been killed off that there are not sufficient full-grown individuals remaining to attend properly to the females landing on the islands. Large numbers of females are, however, slaughtered by the pelagic sealers cruising in Behring Sea during the months of August and September. In this pelagic sealing, eight out of every ten animals taken are shot whilst asleep on the surface of the water. Most seals when shot will float for some considerable time, and it is a curious fact that

Cape Sea Lion (*Otaria pusilla*).

these sleeping seals hardly ever sink when struck. Those that are lost by sinking—from five to seven per cent. of the whole number killed—are, as a rule, awake, and when shot are struck in the throat. The reason for their sinking is supposed to be the escape of the air through the holes made by the buck-shot. Mr. Snow remarks with regard to those seals shot in the open sea, that they "all have pups on the 'rookeries,' which, being unable to shift for themselves, die of starvation. The fault lies with the regulations formulated by the Behring arbitrators, who have made the close season from the 1st of May till the 1st of August. May is too early, and is unfair to the pelagic sealers. Had the close season been from (say) the 30th of June to the 30th of September it would have been far better."

The skins are packed with salt in casks, each of which contains from forty to forty-five; such casks being forwarded to London in batches of from two to three hundred. On arrival the skins are sorted according to size, the largest being known to the trade as "middlings," while the smaller are classed as "pups" of various descriptions. A few years ago the average value per skin was seventy-eight shillings.

Regarding the process of preparation, after the remains of the blubber have been removed and the skins trimmed, Mr. Poland tells us that the pelts "are warmed on the fur side in the stove room and placed across the unhairer's beams, and the top hair is then removed with a blunt knife. The hair comes off in handfuls. The skins have to be kept warm during the whole process. . . . . The skins now have only the fur left, which is of a light drab colour. They are then tubbed—generally by machinery—in order to soften the leather, and shaved (old process), repaired, or sent as they are to the dyers." This dressing process occupies from one to three months, and the subsequent dyeing is still more complex. Although this part of the trade was formerly almost exclusively in English hands, it is now largely shared by the French. After dyeing, the skins are again scraped or shaved, and cleaned by being put in a revolving drum among a quantity of sawdust. Certain fine hairs, technically known as water-hairs, have still to be removed, this being effected by a special machine. Finally, the skins are trimmed, and sorted ready for the market.

The yearly catch of seals in the Commander Group is estimated at from forty to fifty thousand, the skins being packed in much the same manner as are those from the Prybiloffs, but they are not worth so much. Of recent years a variable number of skins of this species have been imported from Japan, the total varying from two to twelve thousand annually.

The northern sea-bear is the only fur-seal inhabiting the northern hemisphere; but there are at least three species found to the south of the Equator. The whole of these southern seals differ from their northern cousins externally in the greater length and narrowness of the muzzle—which is also more depressed—as they do by the smaller extent of skin projecting beyond the extremities of the toes of the hind flippers. In colour they are generally more distinctly grey than the northern species.

The finest skins from the southern seas appear to be the product of the South American or Falkland Island sea-bear (*Otaria australis*), which is found along the South American coast from Chili on the western side, and the mouth of the Rio de la Plata on the eastern side, to the extreme south, and reappears in the Antarctic lands, such as South Georgia and the South Shetlands. From the coasts of continental South America, northwards of Patagonia, these seals have to a great extent disappeared, but are more common on some of the adjacent islands, such as the Galipagos Islands. It will be found stated in some works that these seals occur on the coasts of Lobos (Seal) Island, near Monte Video; but the species found there, and also on some rocks close to the watering-place of Mar del Plata on the Argentine coast, is, we believe, the southern sea-lion (*O. jubata*), which is a hair seal. In the Falklands and South Shetlands, where they were formerly so free from fear of man as not to attempt an escape when their fellows were killed, they are more abundant. During the voyage of the *Challenger* these seals were found in

* For much of the information here given the author is indebted to two esteemed correspondents—Dr. C. H. Merriam, of Washington, and Mr. Snow, of Yokohama—who have pointed out certain erroneous statements unfortunately made in the "Royal Natural History."

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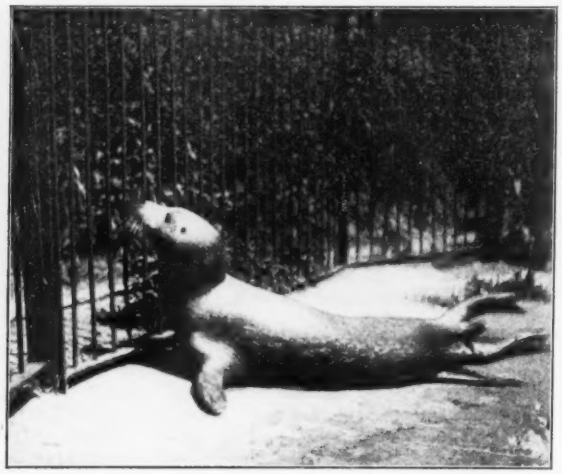
some numbers on Kerguelen Land and Crozet Island, and they also inhabit, or inhabited, several other islands in the Indian Ocean, such as Marion, Prince Edward, St. Paul, and Amsterdam, although often described as a distinct species under the name of *O. gazella*.

The South American fur-seal affords one of the saddest examples on record of ruthless and short-sighted destruction. Soon after its discovery over a million pelts are stated to have been obtained from South Georgia, and nearly an equal number from Desolation Island; while in the year 1800 considerably more than a hundred thousand were shipped from the former locality. Again, in 1821-22, over three hundred thousand skins are stated to have been imported into London from the South Shetlands alone. At the present day the race has been more than decimated, both in South Georgia and the South Shetlands; and in 1887 the number of skins from those



Common English Seal *(Phoca vitulina)*.

islands imported into London numbered, according to Mr. Poland, only a couple of hundred. There is some uncertainty with regard to the imports from the Falklands, as a confusion seems to have arisen between this seal and the southern sea-lion.

Much the same story is told with regard to Crozet and Kerguelen Islands, which, as our readers are doubtless aware, are small barren rocks, rising in the middle of the Indian Ocean some distance southwards of the tropic. In his narrative of the *Challenger's* voyage Lieutenant Spry wrote that "the manner in which the seal fishery is carried on in the surrounding seas is both extravagant and destructive, for at the time of the discovery of this [Kerguelen] island it swarmed with sea-elephants, whales, and fur-seals. On this becoming known it soon became a favourite cruising ground for those engaged in the trade. This led, in an incredibly short space of time, to the reduction of all these species to a mere remnant, and in a few years their utter extinction is sure to follow." This prophecy has not, however, been strictly fulfilled, as it is stated of late years the seals, on account of the absence of molestation, have tended to increase somewhat in numbers. From St. Paul and Amsterdam Islands, lying to the north of Kerguelen, the seals appear to have been completely extirpated; and the cruisers despatched of late years from the Cape to Prince Edward and Marion Islands have been unsuccessful.

Nearly allied to the last is the Cape fur-seal (*Otaria pusilla*), which now seems to be restricted to the coasts of South Africa and the neighbouring islands, although it probably formerly inhabited Tristan d'Acunha. As a species it is characterized by the comparative straightness of the facial profile, the length of the ears, the sharp, overhanging muzzle, and the elongated bristles of the upper lip. Although this seal is still fairly abundant, the pelts are of small value owing to the shortness of the under-fur, those of young animals being superior in this respect to the adults. Indeed, the pelts of old males—the old "bulls" of the sealers—are often only usable for leather. Although formerly as many as seventy or eighty thousand skins were imported annually into London, the number now is much reduced. The skins of young animals—"pups"—are frequently used without the removal of the outer hair. The most productive sealing-grounds for this species are certain small islands in Algoa Bay.

All the southern fur-seals are very similar to one another, so that their specific determination is a matter of great difficulty. But it now appears that the Australasian seas are inhabited by a single species known as the New Zealand fur-seal, its scientific title being *Otaria forsteri*, although the name *cinerea* has been applied to the female. Although in greatly diminished numbers, this seal is still found in New Zealand and on the southern coasts of Australia and Tasmania. During the earlier years of Australian history it occurred in vast numbers, upwards of four hundred thousand skins being exported during the years 1814 and 1815. Flinders gives a graphic account of the hosts in which it frequented the shores of Passage Point, to the north-east of Tasmania, in his time. Reckless destruction has, however, done its usual work, and now the species appears to be comparatively scarce.

The above exhausts the list of well-defined species of fur-seals, which alone afford the best true sealskin. There is, however, no hard-and-fast line of division between fur-seals, or sea-bears, and hair-seals, or sea-lions, some of the latter having a small amount of under-fur mingled with the outer fur. The skins of some of these hair-seals are more or less used in the fur trade, but apparently in most cases without the removal of the outer fur. In regard to the small Californian sea-lion (*O. gillespiei*), which inhabits both sides of the North Pacific, and is specially preserved on the Farralone Islands off San Francisco, it seems, from Mr. Poland's account, that the fur of the back is capable of yielding a poor class of sealskin.

None of the true seals (*Phocidæ*) have under-fur, and their pelts are consequently used either for manufacture into leather or as fur which does not come under the designation of "sealskin." For rough purposes some use is made of the fur of the common English seal (*Phoca vitulina*), although the majority of skins, like those of most of the members of the family, are converted into leather. More use appears, however, to be made of the fur of the Greenland seal (*P. grænlandica*), Mr. Poland remarking that, after the skins have gone through the preparatory processes, they are "dyed black or brown, the former being used for military purposes (Hussar or Fusilier busbies), and also a few for fur, such as edgings for robes, etc. The brown skins are used for fur purposes, and the inferior qualities find a ready sale in France." From five to ten shillings is the usual value of the skins of this species.

To give some idea of the immense extent of the trade in seal pelts, it may be mentioned, in conclusion, that, according to a recent estimate, upwards of one hundred and eighty-five thousand fur-seals and eight hundred and seventy-five thousand hair-seals are annually slaughtered to meet the requirements of the world. No wonder the whole tribe is in danger of extermination!

HOW TO OBSERVE AN EARTHQUAKE.

By Charles Davison, Sc.D., F.G.S.

THE phenomena of earthquakes attain a very simple form in this country. To realize this we have only to compare the severest of recent British shocks with one of the great disturbances of other lands: say the Essex earthquake of 1884 with the Charleston earthquake of 1886 or the Japanese earthquake of 1891. In the former case, though many buildings were damaged and chimneys thrown down, the shock only lasted a few seconds; there were no great fissures in the ground, no crumpling of railway lines, no changes in the earth's surface features, such as the compression of river valleys or changes of level along lines of fault. There was some, though comparatively little, derangement of the underground water system. Two months after the earthquake a single slight shock was felt, that would hardly have attracted any notice had it not been for the interest already aroused in the subject. How different is this from the case in Japan! During the day following the disastrous earthquake of 1891 no less than three hundred and eighteen shocks occurred. The daily number, of course, rapidly declined; but before little more than two years had passed, as many as three thousand three hundred and sixty-five shocks were recorded at an observatory situated a few miles from the chief centre of disturbance.

The simple character, the short duration, and the isolation of British shocks are distinct aids to their observation; the attention is not distracted by a multiplicity of details. As the shocks are almost invariably slight, panic and the consequent exaggeration of description are to a great extent avoided. Their rarity is even, in one sense, a point in their favour. This is especially the case, as I have often found, when a seismologist endeavours to collect information from observers in different places, for those who have felt only one or two shocks in their lifetime retain for long the vivid impression they produce.

On the other hand, previous inexperience of earthquakes militates against their accurate observation. The shock begins so suddenly, and is often of such brief duration, that, almost before its true nature is recognized, it may be over and all opportunity for detailed study gone. In such cases, while some points stand out clearly enough and can be easily described, especially with the aid of guiding questions, others of perhaps equal importance escape notice, or the recollection of them is afterwards too indistinct or confused to be reproduced without uncertainty or error.

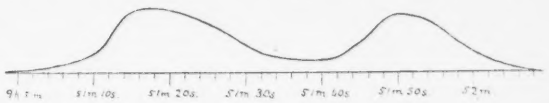
It is not difficult, however, to attend to the principal phenomena—those which will be of the greatest service in determining the surface position of the centre of disturbance and in throwing light on the nature and origin of the earthquake. To describe these phenomena and to point out others which are less deserving of notice may be of some assistance to those who live in the districts which are occasionally visited by earthquakes, and who are desirous, when one does occur, of making the best use of the brief time at their disposal.

It should be mentioned at the outset that the nature or order of the earthquake phenomena may vary much at different points of the disturbed area. At a place not far from the centre of the area, a low, rumbling sound is first heard; this gradually becomes louder, and after one or more seconds a slight tremor is felt, both sound and movement increase together in intensity, and then gradually die away, the sound lasting a few seconds after the movement ceases to be sensible. At its commencement the tremor resembles that produced in a building by a passing carriage or train, but, as it gets stronger, separate vibrations are perceptible. There is, indeed, no real distinction, except in magnitude and duration, between the tremulous motion and the perceptible vibrations. The movement sometimes, but not always, ends with tremors like those at starting.

At places near the boundary of the disturbed area the phenomena are of a simpler nature. If the shock be a strong one, and the disturbed area consequently large, it is possible that no sound at all may be heard, and the only thing observed is a more or less feeble movement. But in most earthquakes in Great Britain the sound is heard as far as the shock is felt. In such cases, at a place some distance from the centre, the sound may be heard first and may cease entirely before any motion is felt, or, at any rate, soon after it begins. The instant when the sound is loudest thus precedes the instant when the shock is strongest.

Very frequently, after a pause of a few seconds, the same phenomena are repeated with greater or less intensity, the movement and sound nearly or quite dying away in the interval.

In describing the nature of the shock it may be convenient to distinguish the tremulous motion from the principal vibrations, applying the latter term (principal vibration) to each distinct and complete to-and-fro movement. When the separate vibrations are so rapid and small as to be imperceptible from one another, the term "tremors" or "tremulous motion" should be used. However carefully written a description may be, it will always gain in value by the addition of a curve like that in the accompanying figure. This curve shows, for the great



Charleston earthquake of August 31st, 1886, how the intensity varied during the course of the shock.

Very often a sense of direction is perceptible, and in many descriptions some importance seems to be attached to this. If, however, these directions as observed at different places are all plotted on a map (I am speaking here of British earthquakes), they are found to be governed by no definite law; they do not diverge from any particular point or area. One reason, no doubt, is that the direction itself at any place may change during a shock; but even if this were not the case, the apparent direction within a house is so largely governed by the direction in which the house itself vibrates—*i.e.*, by that of its longer axis—that observations on direction are generally of little, if any, value. It does not seem advisable, therefore, to pay much attention to this point, and the time often given to it may, as a rule, be more profitably bestowed.

Another point on which valuable time is often wasted is the determination of the time of occurrence. The first impulse of an observer, when he begins to feel a shock, seems to be to pull out his watch. Now, if the watch were very carefully regulated, or if its deviation from correct Greenwich time could be ascertained soon afterwards, it would be of the highest importance to determine the time of occurrence, especially if this could be done accurately to within a few seconds. But at the present day comparatively few watches can be depended on to this extent, and not many persons are able within a few hours to compare their watches with an accurately regulated clock. It is seldom, indeed, that observations of the time are of any use for determining the velocity with which the earth-wave travels. It should be remembered, too, that an appearance of accuracy, where none really exists, is easily given, and is most mis-

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leading; it would be better far if such an observation had never been made. As a general rule, therefore, when an observer is unprovided with a really good watch, he will spend his time more usefully in giving his whole attention to the nature of the shock and the accompanying sound. When the earthquake is over he should then record the time, and it is not difficult to estimate the brief interval which has elapsed. When, as is often the case in this country, successive earthquakes are separated by months or years, an error of a minute or two is not of much consequence. The time, however, should always be recorded as nearly as possible, if only for the purpose of identifying the shock with that observed by others. Sometimes also it is useful in tracing a doubtful or reported earthquake to its real origin, such as the firing of heavy guns at a distance, or the bursting of a meteor.

The preceding remarks apply in part to the duration of the shock. There is no difficulty, of course, in determining this with some accuracy; but here again the time can be more usefully employed. The duration is an element of little importance, unless it is determined by a seismograph, because the instants at which the movement begins and ceases to be perceptible depend entirely on the sensitiveness of the observer; and this varies in different persons, and even in the same person at different times. For all practical purposes, the direction can be estimated with sufficient accuracy when the earthquake is over. The observer should place himself in the same position as that in which he felt the shock and then imagine it repeated, marking the beginning and end, the aid of another person being obtained to time the interval.

One of the most important points to which an observer can direct his attention is the intensity of the shock. If nothing else but the mere occurrence of the sound and shock were noted, this element should not be omitted. Fortunately we are provided with a rough scale of seismic intensity, which has met with general adoption in nearly all countries where earthquakes are studied, and which is accurate enough for most purposes, besides being most easy to apply. This is known as the "Rossi-Forel" scale of seismic intensity.* The different parts of Question 6 in the list at the end of this paper refer to degrees iv. to viii. of this scale, the degree being added in brackets after each part of the question. One or two remarks should perhaps be made on this subject. In his own notes, at any rate, the observer should record a full answer (not merely "Yes") to each part of the question when it can be so answered. It should, for instance, be stated whether, in answer to the first part, doors, windows, etc., all rattled, or only one or the other; and whether the rattling was violent or slight. Answers, again, should be written to all parts of this question, especially if in the negative. The last affirmative answer of course determines the intensity of the shock. On this subject of intensity, however, the observer should not rest satisfied with his own impressions. He should make inquiries of his neighbours and others situated at a short distance in the same town or village, for the intensity often differs considerably at two points which are not very far apart.†

The last subject which need be referred to here is the observation of the sound phenomena. These, as a rule, are somewhat neglected, and yet they may prove to be of considerable importance, especially in concert with a large number of similar observations made elsewhere. The earthquake sound should of course be carefully distinguished from that produced by the rattling of loose objects, or, in rare cases in this country, by the fall of masonry. There is, indeed, little risk of confusion, for the earthquake sound does not resemble very closely any ordinary noise. On this account it is somewhat difficult to describe; but it is often compared to thunder (especially the low roll of distant thunder), the passage of a traction-engine or heavy vehicle along a rough road, the dragging of furniture across the floor of a room overhead, the roaring of a chimney on fire, or the rush of a gust of wind. Sometimes it is more or less short and abrupt, like the firing of distant cannon, the fall of a heavy body, or the slamming of a door; and occasionally it resembles a succession of these, such as would be produced by a hard and heavy ball rolling down a short flight of stairs. Particular attention should be paid to the time relations of the shock and sound—whether the beginning of the sound precedes, coincides with, or follows the beginning of the shock, and similarly with regard to the end. But on this sufficient is said in the questions given below. A rough curve might with advantage be drawn, showing the variation in intensity of the sound, and, if possible, this curve should be combined in the same figure with the curve of intensity of the shock—a dotted curve, say, for the sound, and a continuous curve for the shock. Such a figure would exhibit at a glance nearly every detail (except the absolute intensity and the time of occurrence) which it is desirable or necessary to observe.

The order in which the observations should be made and recorded is of great importance. The following is suggested as a convenient one, though the experience or inclination of each observer may lead him to adopt various modifications:—1. While the earthquake lasts the whole attention should be given to observing the nature of the shock and sound and their relations to one another; the variations in intensity and character of each. 2. Immediately the earthquake is over, take the time (in the following order: fraction of a minute or second, minute, hour), and estimate the interval between the instant when the shock was strongest and the instant of taking the time. 3. Write notes on the nature of the shock and sound, and their relations to one another. 4. Estimate the duration of the shock and sound, and the intervals between the beginning of each and the end of each. 5. Record the intensity. 6. Write notes about the position and occupation at the time of the earthquake.

LIST OF QUESTIONS.

1. *Name of the Place* where the earthquake was observed?

2. *Situation of the Observer:* (*a*) Whether indoors (and on which floor of the house) or in the open air? (*b*) How occupied at the moment of the shock?

3. *Time* at which the shock was felt?

4. *Nature of the Shock:* (*a*) Was any tremulous motion felt before the principal vibrations, and for how many seconds? (*b*) How many principal vibrations were felt, and for how many seconds did they last? (*c*) Was any tremulous motion felt after the principal vibrations, and for how many seconds? (*d*) Did the shock gradually increase in intensity and then gradually die away, or were there two or more maxima or series of vibrations, and, if so, how many were there? what were the intervals between them? and what was the order of their intensity? (*e*) Were the principal vibrations strongest near the beginning, middle, or end? (*f*) Was any vertical motion perceptible, and, if so, was the movement first upward and then downward, or *vice versâ?*

5. *Duration of the Shock* in seconds, not including that of the accompanying sound.

* For a full translation of the scale, *see Nature*, Vol. XLII., 1890, p. 349.

† See a paper by Prof. J. Milne, "On a Seismic Survey made in Tokio in 1884 and 1885." *Japan Seismol. Soc. Trans.*, Vol. X., 1887, pp. 1—36.

6. *Intensity of the Shock:* Was it strong enough (*a*) to make windows, doors, fireirons, etc., rattle (iv.)? (*b*) to cause the chair or bed on which the observer was resting to be perceptibly raised or moved (v.)? (*c*) to make chandeliers, pictures, etc., swing, or to stop clocks (vi.)? (*d*) to overthrow ornaments, vases, etc., or cause plaster to fall from the ceiling (vii.)? (*e*) to throw down chimneys, or make cracks in the walls of buildings (viii.)?

7. *Sound Phenomena:* (*a*) Was any unusual rumbling sound heard at the time of the shock, and, if so, what did it resemble? (*b*) Did the beginning of the sound precede, coincide with, or follow the beginning of the shock, and by how many seconds? (*c*) Did the end of the sound precede, coincide with, or follow the end of the shock, and by how many seconds? (*d*) Did the sound entirely precede the shock, and, if so, what was the length in seconds of the interval between the end of the sound and the beginning of the shock? (*e*) Did the sound become gradually louder and then die away, or were there several maxima of intensity? (*f*) Did the sound change in character at or about the time when the strongest vibrations were felt? (*g*) Was the sound loudest before, at, or after the instant when the shock was strongest?

THE FACE OF THE SKY FOR AUGUST.

By HERBERT SADLER, F.R.A.S.

THE decrease in solar spots is still noticeable. Conveniently observable minima of Algol occur at 3h. 19m. A.M. on the **14th**; at 0h. 8m. A.M. on the **17th**; and at 8h. 56m. P.M. on the **19th**.

Mercury, Venus, and Jupiter are all too near the Sun this month for the observer's purposes.

Mars is now becoming visible in the evening sky. On the **1st** he rises at 11h. P.M., with an apparent equatorial diameter of 8·2″, the defect of illumination on the *p* limb amounting to 1¼″. On the **7th** he rises at 10h. 46m. P.M., with a northern declination of 17° 41′, and an apparent equatorial diameter of 8½″. On the **12th** he rises at 10h. 34m. P.M., with a northern declination of 18° 27′, and an apparent equatorial diameter of 8¾″. On the **19th** he rises at 10h. 17m. P.M., with a northern declination of 14° 10′, and an apparent equatorial diameter of nearly 9″. On the **26th** he rises at 10h. 2m. P.M., with a northern declination of 20° 15′, and an apparent equatorial diameter of 9·2″. On the **31st** he rises at 9h. 50m. P.M., with a northern declination of 20° 47′, and an apparent equatorial diameter of 9½″, the *phasis* amounting to 1·4″. He describes a direct path through Leo during the month, passing through the Hyades towards the end of it.

Saturn is still an evening star, but should be looked for as soon as possible after sunset. On the **1st** he sets at 10h. 53m. P.M., or 3h. 8m. after the Sun, with a southern declination of 13° 30′, and an apparent equatorial diameter of 16¼″ (the major axis of the ring system being 39½″ in diameter, and the minor 13¾″). On the **7th** he sets at 10h. 30m. P.M., or 2h. 53m. after the Sun, with a southern declination of 13° 34′, and an apparent equatorial diameter of 16″. On the **17th** he sets at 9h. 52m. P.M., or 2h. 36m. after the Sun, with a southern declination of 13° 45′, and an apparent equatorial diameter of 15½″. On the **31st** he sets at 8h. 59m. P.M., or 2h. 12m. after the Sun, with a southern declination of 14° 3′, and an apparent equatorial diameter of 15″ (the major axis of the ring system being 37½″ in diameter, and the minor 13½″). He describes a short direct path in Libra during the month, being about 2¼° north of *α* Libra (3rd magnitude) on the **12th**. Iapetus is in superior conjunction on the early morning of the **11th**.

Uranus is an evening star, but should be looked for as soon after sunset as possible, and his great southern declination militates against his successful observation. On the **1st** he sets at 11h. 2m. P.M., with a southern declination of 17° 37′, and an apparent diameter of 3·7″. On the **31st** he sets at 9h. 2m. P.M., with a southern declination of 17° 45′. He describes a short direct path in Libra during the month.

As Neptune does not rise till about 10h. P.M. at the end of the month, we defer an ephemeris of him till September.

This month is one of the most favourable ones in which to observe shooting stars. The most noted shower is that of the Perseids, with a radiant point at the maximum display on **August 10th** in R.A. + 11h. 52m. + 56°. Observations of this region of the heavens with an opera-glass will, no doubt, show stationary meteors, or meteors which shift their positions very slowly. Their places, and the direction of their shift, should be noted for the purpose of determining whether the radiant is a geometrical point or a circle, on an elliptic area, as suggested with regard to the November meteors (*Monthly Notices of the Royal Astronomical Society*, Vol. XLVII., pp. 66–73). The radiant point souths at 5h. 37m. A.M.

The Moon enters her last quarter at 6h. 34m. P.M. on the **1st**; is new at 5h. 2m. A.M. on the **9th**; enters her last quarter at 9h. 2m. P.M. on the **15th**; is full at 7h. 4m. A.M. on the **23rd**; and enters her last quarter at 10h. 55m. A.M. on the **31st**. She is in perigee at 6h. P.M. on the **11th** (distance from the Earth, 226,340 miles), and in apogee at 3h. P.M. on the **27th** (distance from the Earth, 251,880 miles). There will be a total eclipse of the Sun on the morning of the **9th**, invisible at Greenwich, and a partial eclipse of the Moon on the morning of the **23rd**; but only the penumbra of the Earth's shadow will be projected on the Moon at Greenwich, the Moon setting before the contact with the umbra occurs.

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

Communications for this column should be addressed to C. D. LOCOCK, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of July Problem.

(A. C. Challenger.)

Author's intention:—1. P to Kt3, etc.

Unfortunately, there is a second and similar solution beginning with 1. R to R4.

CORRECT SOLUTIONS received from H. H. Quilter (both solutions), H. F. Biggs, W. Willby, G. A. F. (Brentwood), C. H. G., H. Le Jeune, and Ubique.

A. S. Coulter.—In self-mate problems, Black is not compelled to defend himself from being mated. His sole object is to avoid mating White.

H. Price.—There is a second solution to your problem, commencing with 1. R to KKtsq, 2. B to B3ch, etc. If you correct it please send a diagram. We insert the challenge below.

C. H. Gaskin.—Thanks; but the want of economy in the construction is fatal.

J. F. Welsh.—The tournament is noticed below.

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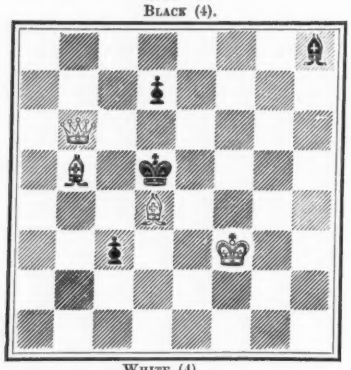
PROBLEMS.

By A. C. Challenger.

No. 1.

BLACK (4).

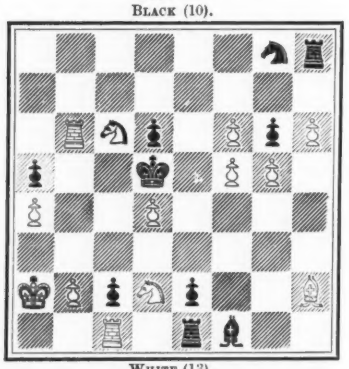


WHITE (4).

White mates in two moves.

No. 2.

BLACK (10).



WHITE (13).

White mates in three moves.

CORRESPONDENCE CHESS.—Mr. Hubert Price, 89, Clarke Street, Ladywood, Birmingham, would be glad to play one or two games, by correspondence, with a strong player.

CHESS INTELLIGENCE.

After a protracted contest, the tournament at Simpson's Divan resulted in the following score:—R. Teichmann, 9; F. J. Lee and L. Van Vliet, 8½; R. Loman, 7; O. C. Müller, 6; E. Cresswell, 5½; and six other scores smaller than 5. Mr. Teichmann was naturally expected to be the winner, and by a larger majority than that of half a game over Messrs. Lee and Van Vliet. However, 9 out of a possible 11 is a good winning score, and the two scorers of 8½ must either have been in exceptional form or have encountered in some cases a weak resistance. Mr. Bird's score of 4 is very disappointing.

Mr. J. W. Showalter has had all the best of a match with Mr. Barry, of Boston. The former is the leading native-born American player, and is expected to take part in the Nuremburg Tournament.

The Amateur Championship of the Southern Counties Chess Union will take place at the Imperial Hotel, Clifton, from September 7th to September 16th. Entrance fees, 10s. each, must reach Mr. T. Letchford, 6, Eastfield Road, Cotham, Bristol, on or before August 15th.

The present score in the Quadrangular Tournament of the Vienna Chess Club is:—C. Schlechter 6, B. Englisch 5½, M. Weiss 5, G. Marco 4.

The *Standard* gives the following list of competitors in the International Tournament which begins this week at Nuremburg:—Blackburne, Burn, Lasker, and Teichmann (England), Janowski (France), Schiffers, Tschigorin, and Winawer (Russia), Schallopp, Tarrasch, and Walbrodt (Germany), Porges (Prague), Maroczy (Buda-Pesth), Pillsbury, Showalter, and Steinitz (U.S.A.), Albin, Marco, and Schlechter (Austria).

Mr. Lasker is a doubtful competitor, and the same, we have always understood, applies to Dr. Tarrasch. Should both these play, it will be the strongest tournament on record, superior even to that of Hastings last summer. Even such a strong player as Mr. Albin will have to fight hard not to occupy the last place. Mr. Maroczy will be remembered as the winner of the Minor Tournament at Hastings last year.

The subjoined game was played in the recent Divan Tournament:—

"Giuoco Piano."

WHITE. (Mr. J. Mortimer.)	BLACK. (Mr. Van Vliet.)
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	3. B to B4
4. Castles	4. Kt to B3
5. P to Q3	5. P to Q3
6. P to B3	6. Castles
7. B to KKt5	7. B to K3
8. QKt to Q2	8. Kt to K2
9. B × Kt	9. P × B
10. Kt to R4	10. P to B4
11. Q to R5	11. P to B5
12. QKt to B3	12. K to Kt2
13. Kt to Kt5	13. P to KR3
14. B × B	14. P × Kt
15. Q × KtPch	15. K to R2
16. Kt to B5	16. Kt × Kt
17. B × Ktch	17. Resigns.

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TWO PLATES.—1. Photograph of the Region of the Spiral Nebula Messier 33 Trianguli. 2. Breakers on a Rocky Coast.

NOTICES.

The numbers of KNOWLEDGE for January and February of 1894 can now be had, price One Shilling each.

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